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Yefim Gordon; original translation by Dmitri Komissarov, additional material by David Donald

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James Martin was a brilliant engineer whose talents proved vital to the Allied war effort. Perhaps his crowning glory was the M.B.5 fighter, the culmination of a family of fighter designs which showed enormous promise. That the M.B.5 was overlooked by the UK political establishment robbed the RAF of what could have easily been the finest fighter of World War II **150**

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American Volunteer Group

The 'Flying Tigers'

Curtiss Tomahawks of the 3rd Squadron, American Volunteer Group are seen on a fighter-bomber escort mission near Paoshan, China, 24 May 1942. On the same day, the AVG base at Paoshan was bombed by the Japanese. The AVG's short existence was characterised by frequent movement between basic airfields which were often abandoned as the Japanese advanced.

For a brief six months, a group of pilots and ground crew recruited from all branches of the US military was the only serious air opposition to the Japanese advance into western China. The 1st American Volunteer Group – The 'Flying Tigers' – has become legend as a band of adventurers fighting the might of Imperial Japan at a time when the United States had no effective response. The AVG deserves its reputation, but much of the truth was distorted by the popular press at the time, and myths about the 'Flying Tigers' have grown ever since.

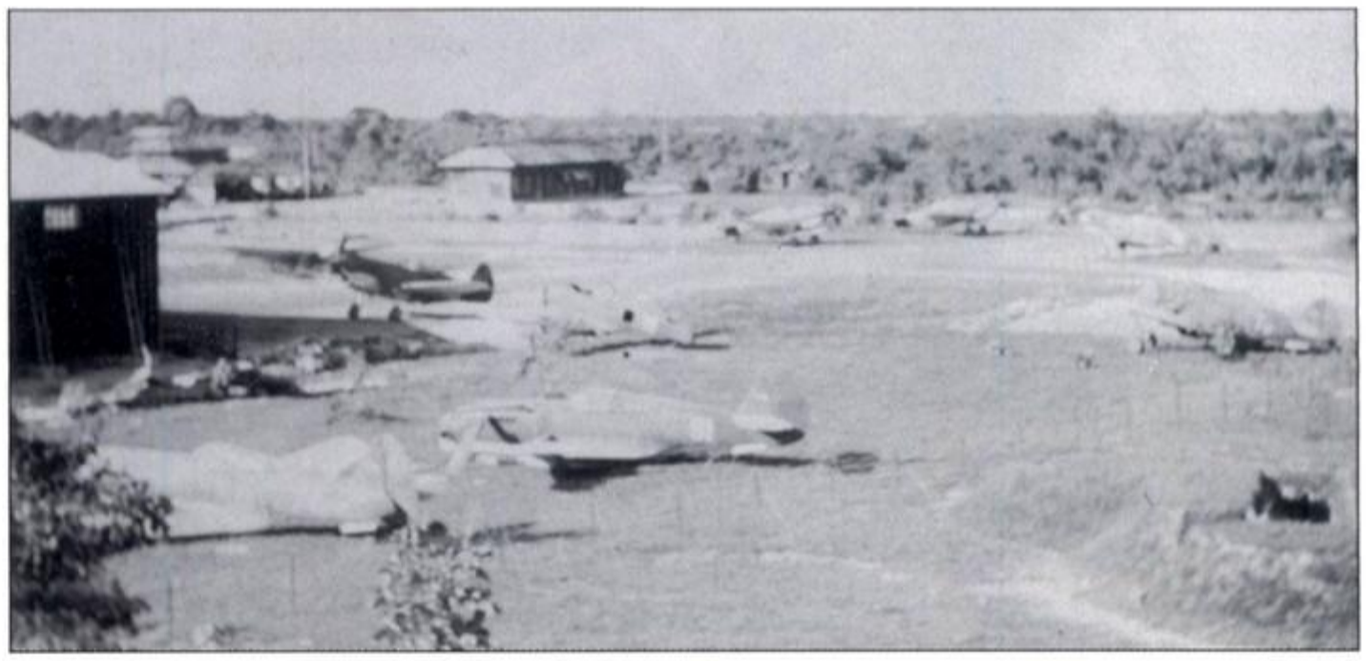
In America in 1942, it was impossible to miss radio and wire-service news reports about the 1st American Volunteer Group, the 'Flying Tigers'. On the home front, a population was uplifted and a vast industrial war effort launched while legend grew around the tiny band of AVG pilots flying Curtiss Hawk 81A-2 (Tomahawk IIB) pursuit ships in defence of the Burma Road. It was the darkest hour of the war, and Japan seemed invincible. And then, the 'Flying Tigers' proved otherwise.

Brought to the China-Burma-India (CBI) theatre as civilians, the 'Flying Tigers' waged a brief war that lasted just under seven months. Their struggle against superior Japanese numbers often seemed hopeless.

Claire Chennault – the headstrong ex-US Army captain and pilot who went to China in the late 1930s in the hire of Generalissimo Chiang Kai-shek to mould an air force – considered the 'Flying Tigers' to be the culmination of years of effort to defend against Japan's aggression in the region. Chennault built an air arm for China long before he created the 'Flying Tigers', but when the American Volunteer Group finally came into being, it received attention back home in a way other aviators in China never had. At a time when the American public was despondent over losses and defeats, the 'Flying Tigers' mounted stiff and tenacious resistance to a Japanese juggernaut that had already seized Manchuria, much of China, Hong Kong, and a major segment of Southeast Asia. The AVG proved again and again that Japan's men and machines were not invincible and that defeat was not inevitable. They became a rallying symbol for the hearts and minds of Americans during a grim episode in history's worst war.

The 'Flying Tigers' were not the first to resist the Japanese war machine – in the late 1930s, Chinese and foreign airmen, notably Soviet volunteers, had done this with considerable bravery. The 'Flying Tigers' probably shot down 115 Japanese aircraft, not the 286 they claimed. They

Claire Lee Chennault, shown later in the war after he had become a lieutenant general, was a noted pre-war aviator. Refused the chance to fly in World War I, he joined the 94th Fighter Squadron in the 1920s and became a flying instructor. In 1937 he took a medical discharge to conduct a survey of the Chinese air force at the behest of Generalissimo Chiang Kai-shek, an assignment which led eventually to the formation of the AVG.



Boeing P-12 pursuits linked by 20-ft (6-m) lengths of rope. Organisational skills, not piloting, became Chennault's forte in China where he was undermined by constant political intrigues and hampered by respiratory ailments: the jut-jawed, Camel-smoking Chennault never flew a combat mission for the AVG himself and was rarely at the airfields where AVG pilots flew and fought.

On 7 July 1937, Japanese forces invaded China from bases in Manchuria, sweeping aside Chinese ground forces and destroying Chiang Kai-shek's tiny air force overnight. Soon afterward, the Generalissimo, as the Chinese leader styled himself, recruited US Army Air Corps pilot Captain Claire Lee Chennault to come to China as an advisor. The purpose of the future 'Flying Tigers' was set on 14 September 1937 when Claire Chennault wrote from China to his friend Captain Haywood 'Possum' Hansell. "Man," Chennault wrote of the unfolding conflict in China, "if the Chinese only had 100 good pursuit planes and 100 fair pilots, they'd exterminate the Jap air force!"

In the meanwhile, Chennault rebuilt a fledgling Chinese air force. He flew a radial-engined Curtiss Mohawk that had been given to him as a gift. Thanks to publicity from journalist Joseph Alsop, the first of many false legends grew – to the effect that Chennault himself shot down 37 Japanese aircraft (or 40, or 50, or 67, enough to make him America's all-time ace of aces) while whipping Chiang's air force into shape. Today, no one seriously believes that Chennault engaged in air-to-air combat in China in the years before the AVG was formed (or, for that matter, afterward), but it made great copy on the news desks of the day.

An overall view of the AVG base at Kyedaw, Toungoo, north of Rangoon shows at least four written-off or cannibalised P-40s. Training operations prior to the AVG's actual combat debut took a heavy toll of the few available aircraft. One pilot wrecked three examples in five days in November 1941, including No. 81 seen at the centre.

Far left: The famous insignia of a winged tiger leaping from a stylised 'V for Victory' was designed at the Walt Disney Studios especially for the AVG. It did not appear on AVG aircraft until mid-March 1942 when the first consignment of decals arrived from the US.

Below: One of the many 'crack-ups' prior to any actual combat was a ground collision at Rangoon between this aircraft, flown by a pilot named Bacon, and that of Robert Sandell, CO of the 1st Squadron. Sandell was killed on a test flight, having scored five victories.

flew no combat missions prior to the attack at Pearl Harbor, although a John Wayne movie showed them doing so. They were widely touted for taking on and defeating Japan's most famous fighter when, in truth, they never saw a Zero. They did not, at first, fly an aircraft bearing the US Army's P-40 designation. (The initial batch of AVG aircraft is identified in published accounts as P-40B, P-40C, or Hawk 81A-3 models. In fact, their factory name plates confirm that they were Hawk 81A-2 models, also known as Tomahawk IIBs. The Tomahawks had no US Army designation, but pilots routinely called them P-40s. By March 1942, the AVG also had a few P-40E Kittyhawk models.)

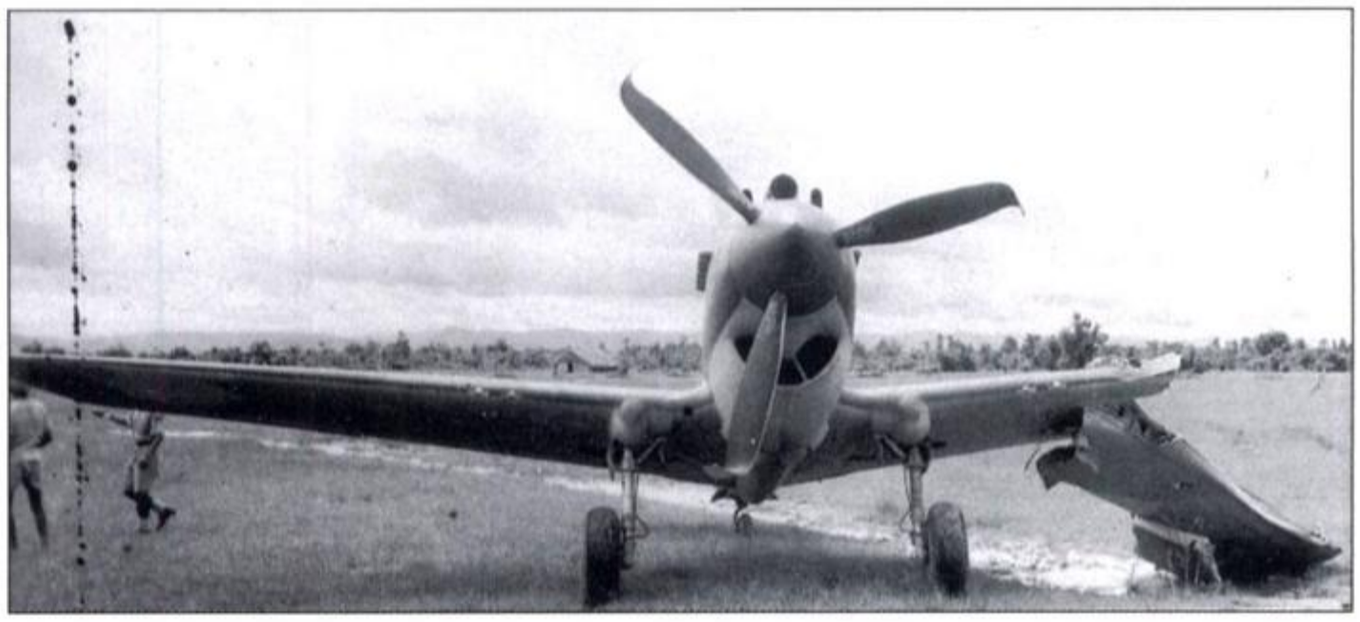
Myths or no myths, the 'Flying Tigers' achieved towering success, much of it to the credit of one man.

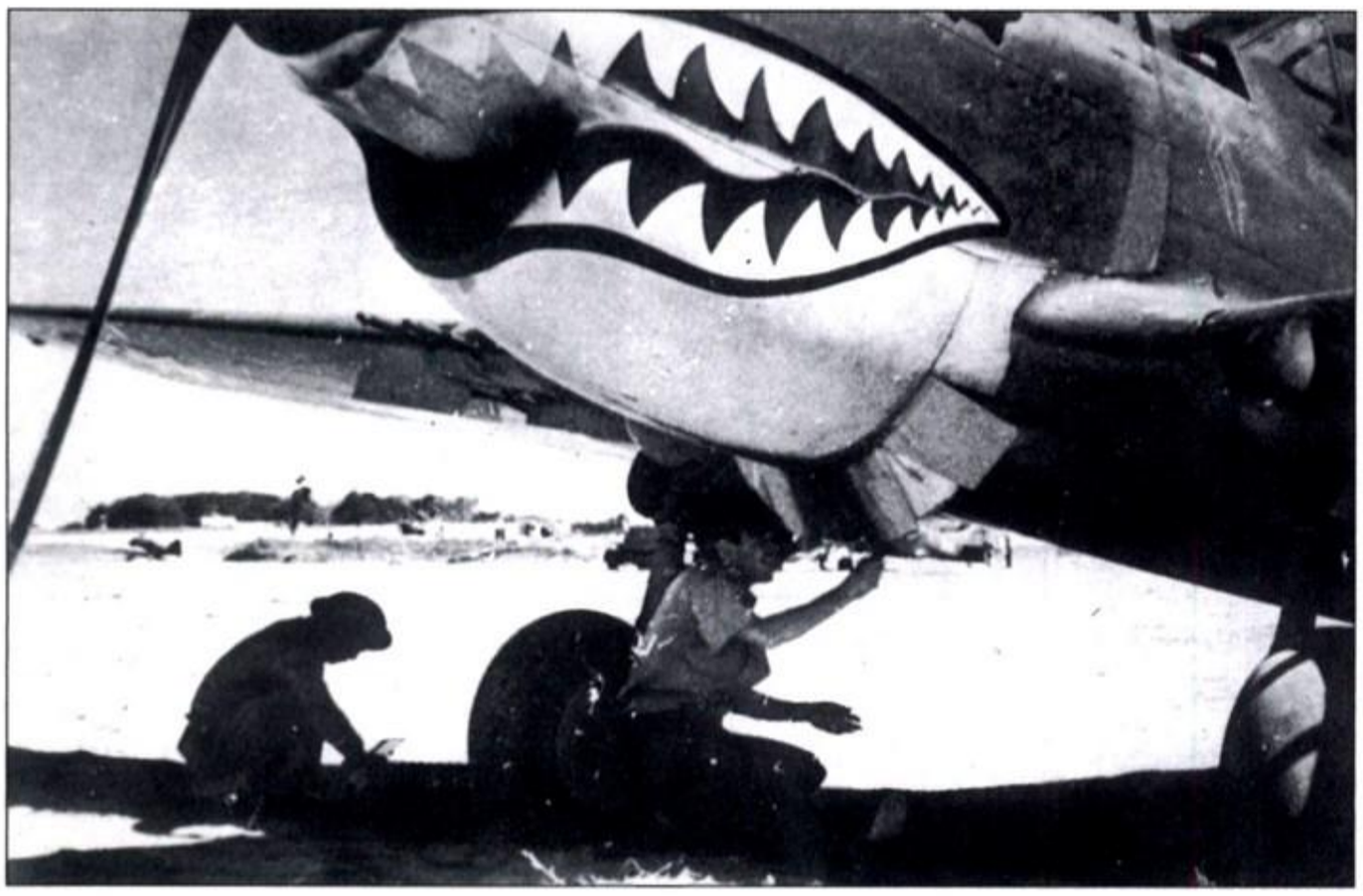
Enter Chennault

Claire Chennault had been an exceptional pilot himself. He had created an aerobatic team, the 'Three Men on a Flying Trapeze', that flew intricate manoeuvres in three

Forming the AVG

Chennault knew, even before writing to Hansell about it, that he would have to get men and machines from abroad to stem the Japanese. Travelling the United States in 1940 in search of pursuit aircraft, Chennault met with Navy Secretary Frank Knox, Treasury Secretary Henry Morgenthau Jr and Washington lobbyist Tommy Corcoran. On 15 April 1941, President Franklin D.





The AVG ground crews were a mixture of Americans, recruited from the US services like the pilots, and Chinese mechanics; all were nominally CAMCO employees. Here, a crew works on the cowl flaps of a 3rd Squadron Tomahawk at one of the Burmese bases.

AVG pilots inspect the rudder of one of their victims, a Ki-27 of the 2nd Chutai, 77th Fighter Sentai which was brought down north of Rangoon in early 1942.

Roosevelt quietly signed an executive order authorising recruitment for the AVG of enlisted men and reserve officers on duty with the US armed forces.

Chennault found that Britain's Royal Air Force had first priority on any warplanes available to be purchased. After a great deal of trial and error, and with support from Washington insiders like the influential Corcoran, Chennault visited the Curtiss-Wright plant in Buffalo, New York. Here was an opportunity to purchase 100 Hawk 81A-2 pursuit ships. Among other distinctions, the 81A-2 had self-sealing fuel tanks which the US Army P-40B did not. The AVG Tomahawk also lacked the Army version's provision for an external fuel tank. On 12 December 1940, during a visit to Washington, Chennault told General George C. Marshall what he knew about the Mitsubishi Zero fighter. In late December, he visited Curtiss-Wright in Buffalo, New York and got what may have been his first look at the Tomahawk fighter.

Recruiting the Tigers

The AVG's Tomahawks were shipped unassembled in crates to Rangoon, where they began arriving on the docks in May 1941. The crates were trucked to Mingaladon airfield and the aircraft were slowly assembled under primitive conditions. By June 1941, Chennault and his helpers had finished the task of recruiting 100 pilots (the figure reached 109, although only 60-70 were ever in the combat zone at one time) and 150 mechanics. An agreement between Chennault and Chiang Kai-shek on 1 August 1941 officially created the 1st American Volunteer Group.

The United States was officially neutral. The recruiting effort on behalf of Chennault was aimed at experienced pilots (although breached, one requirement was two years' experience) but Americans could not legally serve as belligerents. So the greater fiction was maintained that CAMCO (Central Aircraft Manufacturing Company), the nominal employer of the Americans being hired, was somehow a non-military entity. Lured by promises of good pay ($600 per month, plus $500 for every Japanese aircraft shot down), pilots assembled at a San Francisco hotel in the summer and autumn of 1941 and boarded Dutch ships in groups of 20 to 40 to sail for China. On the ships' roster, experienced military aviators like Robert H. 'Bob' Neale and David L. 'Tex' Hill were listed as tourists, actors, or acrobats – anything but military pilots en route to fight a war thousands of miles from home.

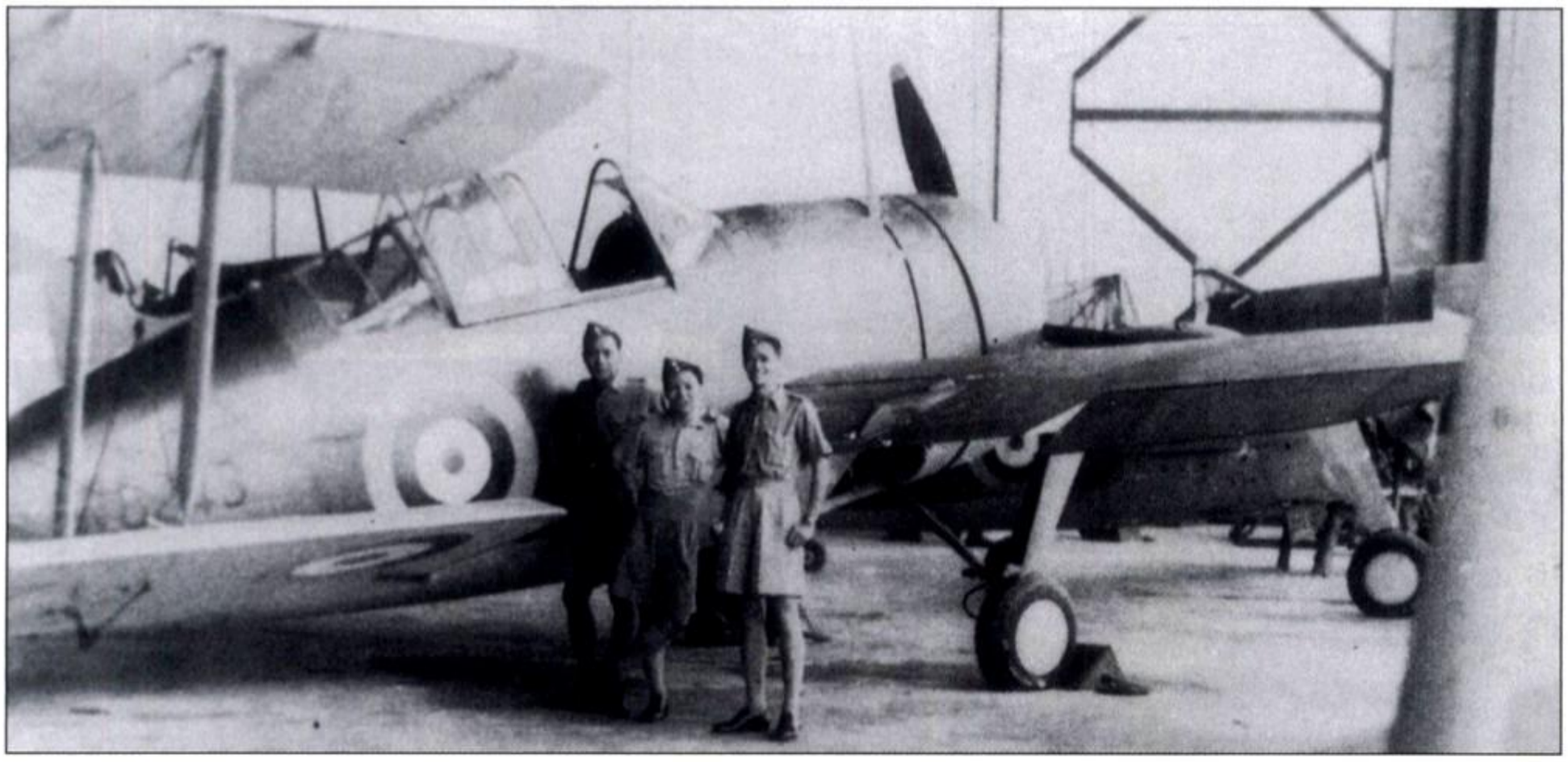
Back in China, Chennault learned that the base at which the AVG was to have trained, near Kunming in southwest China, could not be completed before the onset of the rainy season. From 3 August to 28 November 1941, the Tomahawks at Rangoon's Mingaladon airport were ferried singly or in small groups to the AVG training base at Kyedaw airfield near Toungoo, 175 miles (273 km) north of the Burmese capital. Each aircraft was given a sequential AVG serial number on the fin in small white numerals, for example P-8101, P-8102, P-8103.

In September 1941, the first pilots disembarked at

Aces of the 'Flying Tigers'

Pilot	Pre-AVG	Kills*	Post-AVG
Robert H. Neale	USN	15.55/13.00	Airline pilot
D. L. 'Tex' Hill	USN	11.25/10.25	Inducted USAAF**
George T. Burgard	USAAC	10.75/10.00	Airline pilot
Ken A. Jernstedt	USMC	10.50/3.00	Republic test pilot
Robert A. Little	USAAC	10.55/10.00	KIA 22 May 1942
John V. Newkirk	USN	10.50/7.00	KIA 24 March 1942
William N. Reed	USAAC	10.50/3.00	USAAF. KIFA 1944
William D. McGarry	USAAC	10.25/8.00	POW 24 March 1944
Charles N. Older	USMC	10.25/10.00	USAAF, later 23rd FG CO
Charles R. Bond	USAAC	8.75/7.00	USAAF
Robert T. Smith	USAAC	8.67/8.90	USAAF
Frank Lawlor	USN	8.50/7.00	USN
Percy R. Bartelt	USN	7.00/5.00	USN flight instructor
William E. Bartling	USN	7.25/5.00	'Hump' transport pilot
Frank Schiel	USAAC	7.00/2.00	Inducted USAAF. KIFA 5 December 1942
Edward F. Rector	USN	6.50/4.75	Inducted USAAF
James H. Howard	USN	6.30/2.33	USAAF. Medal of Honor
John R. Rossi	USN	6.25/6.00	'Hump' transport pilot
John G. Bright	USN	6.00/3.00	Inducted USAAF
Ed. F. Overend	USMC	5.83/5.00	Douglas test pilot/ USMC
Tom C. Haywood	USMC	5.25/4.00	Consolidated-Vultee test pilot
Robert W. Prescott	USN	5.25/5.50	'Hump' transport pilot
Robert J. Sandell	USAAC	5.25/5.00	KIFA 7 February 1942
Robert H. Smith	USAAC	5.25/5.00	USAAF
Lewis S. Bishop	USN	5.20/2.00	USN
C.H. Laughlin	USMC	5.20/2.20	'Hump' transport pilot/ USMC

* The first figure is the total air and ground victories credited (and paid for) by the AVG, the second is based on post-war analysis by Frank Olnyk (the author of *Stars and Bars*; Grub Street, 1995) and reflects aerial victories only.
**These 'inducted' pilots stayed on after the dissolution of the AVG and helped establish the 23rd Fighter Group. The only other pilot to do so was Charles W. Sawyer.
KIA= killed in action, KIFA= killed in flying accident



The 'Flying Tigers' were not the only Allied air units defending Burma at the end of 1941. The AVG flew many missions alongside RAF Buffalos, such as those of No. 67 Squadron based at Mingaladon alongside Tiger Moths of the Burma Volunteer Air Force. Seen posing with a 'Brewster' (as the AVG referred to them) are BVAF trainees Sammy Shi Sho, L. S. Main and Peary E. Cho.

Rangoon. The Burmese capital was to be a ripe target of the coming Japanese drive into Southeast Asia. From Rangoon the men travelled to the town of Toungoo where they occupied barracks at the British Kyedaw Airdrome – huts made from bamboo and teak which were sparsely furnished with folding cots. The heat, humidity, jungle surroundings and mosquitoes began to take their toll immediately. Some of the men were almost constantly ill while trying to fight a war with inadequate support at the tail end of an almost non-existent supply line.

Low morale

After delays, training with assembled Tomahawk pursuit ships began at Toungoo (Kyedaw). At Kyedaw, where the AVG formed and the coming defence of Rangoon was debated, pilots were appalled by the living conditions. Kyedaw basked in heat and humidity. The food was indifferent. Dysentery and malaria became commonplace. Chennault (who visited Kyedaw from Kunming on 22 August 1941) insisted on a far more severe training regimen than the pilots had expected, and although the men recognised the need to learn – more than half had never seen a Curtiss pursuit ship before – morale and motivation were initially low.

The Curtiss 81A-2 Tomahawk typified American capabilities of the time and was a better fighter than has often been credited. It was solidly built, and featured twin 0.50-in (12.7-mm) machine-guns firing through its propeller and two 0.30-in (7.62-mm) guns in each wing. The Tomahawks arrived with neither gunsights or guns installed. In the spirit of improvisation, the AVG created a gunsight of its own and armed some of its Tomahawk with wing 7.92-mm guns instead of the 7.62-mm weapons.

The Allison V-1710-C15 inline engine provided slightly more than 1,000 hp (746 kW) and the Tomahawk could cruise at 280 mph (450 km/h) with a maximum speed of 350 mph (563 km/h). As AVG pilot John V. ('Scarsdale Jack') Newkirk discovered, there were glitches. The

Left and below: The AVG was scrambled many times in defence of Rangoon and achieved some notable successes during the many air raids on that city. Head protection for the ground crew was essential as the 'Flying Tigers' bases themselves were frequently attacked.

Tom Haywood was the pilot of P-40 '49', the aircraft illustrated opposite, when it was photographed by 'R.T.' Smith in early 1942. Haywood scored two kills over Army Type 97 ('Sally') bombers in the Christmas Day 1941 air battle while in another aircraft.

Allisons had leaking front thrust bearings, which were replaced in the field by attaching a plate to the bottom of the thrust bearing plate to act as a sump.

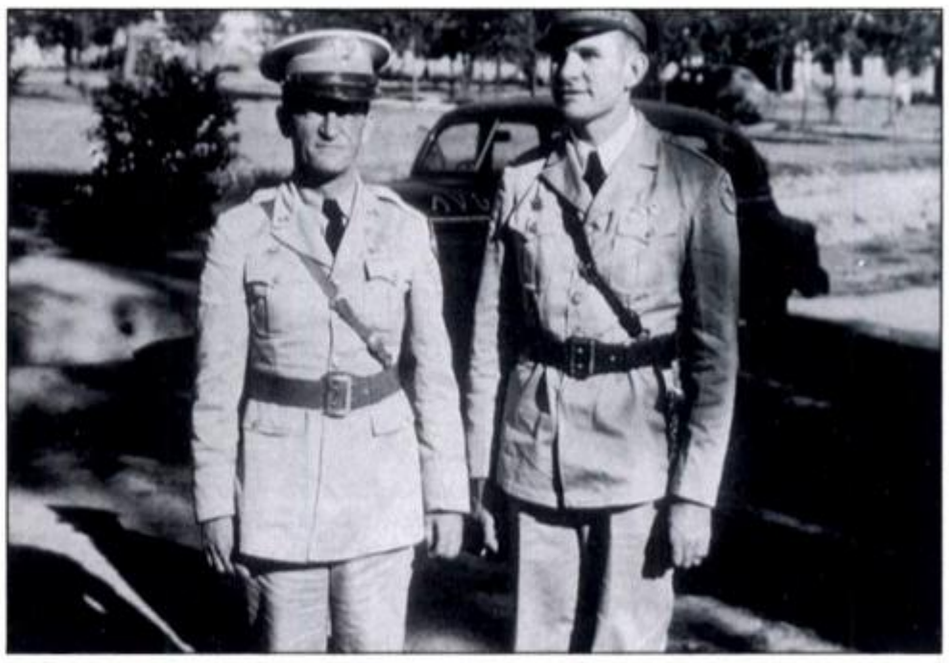
From the beginning, every aspect of flying was dangerous in this primitive setting. On 8 September 1942, pilots John D. Armstrong and John G. 'Gil' Bright were dogfighting when they suffered a mid-air collision that tore one wing off each Tomahawk. Bright in aircraft P-8112 pulled back his canopy, unstrapped, and was catapulted into space where, somehow, his parachute opened – but Armstrong in P-8117 was killed. On 22 September, P-8126 spun in, killing Max C. Hammer. On 25 October, P-8125 exploded in mid-air and its pilot, Peter W. Atkinson, was killed after being blown clear of the aircraft, still strapped into his seat and probably unconscious.

Battle tactics

Chennault taught his pilots from the beginning that there was no way they could dogfight the Japanese. They would dive to the attack, fire on the enemy, and continue in their dive to pull up to make another pass. If they got in trouble with an enemy on their tail they could attempt to outrun him or split-S and dive down into the fight.

There is dispute about how much Chennault knew about an aircraft his pilots never faced in combat – the Mitsubishi A6M Zero, or Type 0, naval fighter that was destined to become Japan's most famous aircraft. The Japanese navy had a detachment of early A6M2 Type 11 Zeros operating in China – and apparently from Hanoi's Gia Lam airport – in co-operation with the Japanese army, from 19 August 1940 until 31 August 1941. One was captured as early as November 1940 and flown in Chinese markings. This aircraft was moved several times and by late 1942 was in the hands of the 23rd Pursuit Group, which replaced the 'Flying Tigers'. There can be no doubt that Chennault, as main advisor to the Chinese air force, had extensive knowledge of the captured Zero; there is also abundant evidence that no-one in Washington paid any attention to his reports. Ignorance of the Zero was to be painful to Americans later in the war, but had little direct

A group of 3rd Squadron pilots is pictured before leaving on a fighter sweep during March 1942. The varied origins of the AVG pilots are reflected in their attire, notably the mix of A-2 (army) and G-1 (navy) jackets, with one RAF Irvin-type at left.



Seen outside the AVG HQ at Kunming with the staff transport behind are Chennault and his XO, C.B. 'Skip' Adair. Adair had done much recruiting for the AVG, scouring army bases for men with P-40 experience.

effect on the Tigers: the Japanese navy turned matters over to the Japanese army before the AVG was formed, and no AVG pilot ever battled a Zero.

Formidable enough as opponents – even if not Zeros – were the Nakajima Ki-27 fighter with fixed gear and open cockpit, and the Nakajima Ki-43 Hayabusa (Peregrine Falcon) with retractable undercarriage. The latter ship resembled the Zero, and AVG pilots inevitably used the term 'Zero' to mean 'Japanese fighter'.

Beginnings at Kyedaw

As the AVG took shape at Toungoo (Kyedaw), pilots sought a distinctive marking for their aircraft. Here, another myth took shape. Supposedly, a sharkmouth design was chosen because this creature is regarded as fearsome in Japanese folklore. In truth, Japanese people are no more or less scared of sharks than anyone else. On 15 November 1941, Charles Bond wrote into his diary about the selection of the most famous aircraft marking in history:

"While discussing the world situation over coffee after dinner, I noticed a magazine section of a British newspaper on the table. I was attracted by the picture of an Australian [sic] P-40 [AVG pilots routinely referred to their pursuit ships by the US Army designation, although their planes technically were not Army P-40s] on the front page that was exactly like ours, but with one exception – the lower nose section around the oil scoop inlets was brightly painted red, white, and green in the shape of a snarling tiger shark, mouth wide open with teeth exposed.

"Gee! I'm going to paint my P-40 that way. I discussed it with the others and they thought it was a good idea. Fortunately, Chennault likes the idea as well." The picture showing Tomahawks of the Royal Air Force's No. 112 Squadron was in the September 1941 issue of the *Illustrated London News*.

Erik Shilling also claimed credit for devising the sharkmouth motif. Pilot Robert T. Smith, who was always called 'R.T.', remembered, "There was no stencil used for making the sharkmouth, so each pilot simply drew the outline with chalk and then painted the lips, teeth, and eyes according to his own taste."

Curtiss Hawk 81-A2 3rd Pursuit Squadron AVG, Kunming, China 1942

'Flying Tigers' Hawk 81 P-8133 was flown by two regular pilots in AVG service, Frank Swartz and Tom Haywood. Swartz was a navy torpedo bomber pilot before he joined the AVG. He damaged a Ki-27 over Burma with the 2nd Squadron before his death in April 1942 as the result of a bombing raid on the AVG base at Magwe. Tom Haywood, a former USMC fighter pilot, 'inherited' P-8133 although he is not known to have scored any of his four confirmed kills in it. After his AVG service, Haywood worked for Consolidated-Vultee as a test pilot and after the war joined the Flying Tiger Line, the freight airline set up by ex-AVG pilots.

Undercarriage
The undercarriage of the Hawk 81 and other P-40 variants retracted backwards while rotating through 90° to lie flush under the wing. This design was a Boeing patent and a royalty payment was made to Boeing for every unit installed.

Markings
In tune with the spirit of the semi-official nature of the AVG, the 'Flying Tigers' wore numerous unit and personal decorations that would never have been approved by any regular USAAC unit commander. P-8133 did not wear the 'Hell's Angel' insignia of the 3rd Pursuit Squadron, but carried the red fuselage band of this unit. The aircraft also wore one of the 'Flying Tiger' decals created by Henry Porter of Disney and the remains of a misapplied second decal, in addition to the famous sharkmouths. A personal marking, in the form of a cartoon bulldog's head was applied forward of the cockpit, probably by Frank Swartz. The Chinese national insignia applied in all six positions was based around a 12-pointed star which symbolised the 12 two-hour periods of the day.

Armament
Curtiss built the Hawks used by the AVG to a British contract and they were completed without armament. When they arrived in China, a more or less standard P-40B arrangement of two 0.50-in calibre machine-guns in the top cowl and four nominally 0.30-in calibre guns in the wings was fitted. The 'thirties', however, were actually sometimes Chinese-supplied 7.92-mm (0.310-in) weapons of German design. These export versions of the P-40C were not designed to carry drop tanks or bombs, but the AVG devised various methods of fitting them with small bombs and incendiaries.

Powerplant
Power for the Curtiss Model H81-A2 was provided by a nor supercharged Allison V-1710-33 (C-15) engine of 1,090 hp (740 kW). Versions of the V-1710 powered all production models of the P-40 except the P-40F and L.

When Burma fell to the Japanese, the AVG moved its aircraft back into China, with the main base at Kunming. These are the aircraft of the 3rd Squadron at Kunming in late May 1942.

Months later, the AVG acquired decals of an insignia designed by Walt Disney studios – a tiger with all legs outstretched as though in flight, leaping out of the angle of a blue V for victory. Bond saw it as "a cross of a tiger shark (like on the nose of our P-40s), the Asian tiger, and the tiger spirit of a gung-ho American fighter pilot." The Disney tiger appeared on some Tomahawks but not others: by then, the men of the AVG had other issues on their minds.

The 'Flying Tigers' were quickly divided into three squadrons – the 'Adam & Eves' (1st Pursuit Squadron, under Sandy Sandell), 'Panda Bears' (2nd; Jack Newkirk), and 'Hells Angels' (3rd; Arvid 'Oley' Olson). Large tactical numbers were painted on the aircraft at Kyedaw. The first squadron was allocated numbers 1-33, the 'Panda Bears' 34-67, and the 'Hells Angels' 68-99. The whole system of marking aircraft this way broke down within three months as the fortunes of war caused Tomahawks to be reassigned from one squadron to another to make up losses.

War breaks out

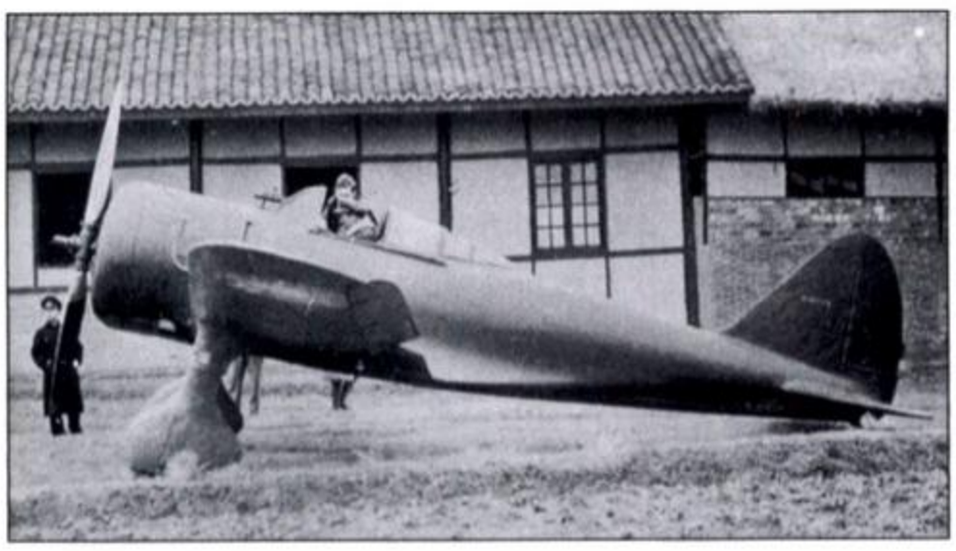
Japan's 7 December 1941 attack on Pearl Harbor gave AVG pilots a new outlook on the war. No longer merely mercenaries, they saw themselves as Americans fighting for their country – and were eager to get into action.

The 'Adam & Eves' and 'Panda Bears' moved to Rangoon on the afternoon of 8 December 1941, their arrival preceded by a bombing attack on the city. A grisly scene of death and destruction only heightened the pilots' desire to get into action.

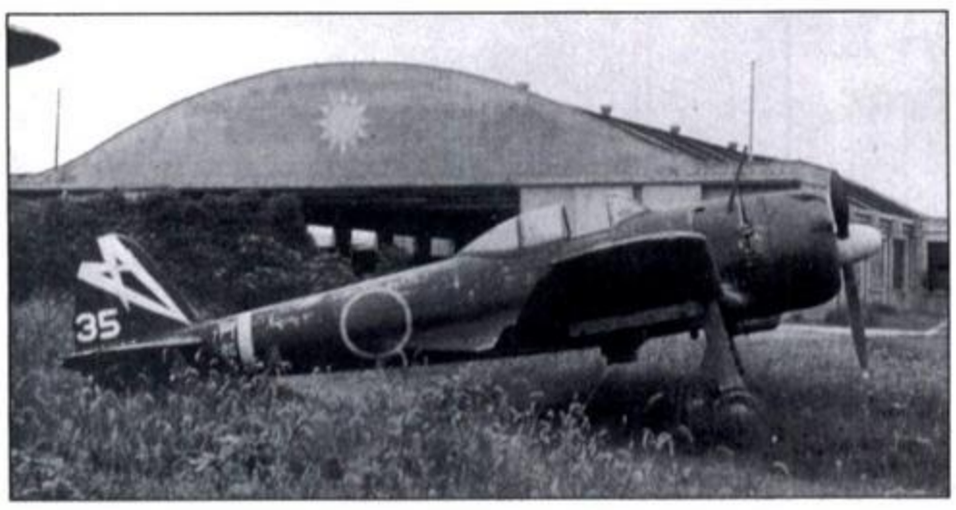
They learned of the Pearl Harbor attack when a radioman ran across the field at Kyedaw to tell the visiting Chennault about the attack. At that juncture, only the aircraft of the 'Hells Angels' were boresighted and ready for combat although, at Chennault's direction, the AVG had attempted to maintain a high degree of readiness. Chennault had worried that a surprise air attack on Kyedaw would be the AVG's baptism of fire, and was working hard to create something he believed in deeply, a warning system manned by spotters.

Chennault also wanted to know what was going on in next-door Thailand, which had officially welcomed Japanese 'visitors' on 8 December. One Tomahawk (P-8153) had been modified for photo-reconnaissance work with a 20-in (50.80-m) Fairchild aerial camera in its baggage compartment. The aircraft retained two guns. On 10 December 1942, in the first official AVG combat action, Erik Shilling drew the mission into Thailand, escorted by Tomahawks flown by Allen Christmen and Edward F. (Ed) Rector. The trio made a marathon cross-country flight with stops at Mingaladon and Tavoy, and flew to Bangkok at 26,000 ft (7925 m). Shilling took plenty of photos and the trio returned safely, unchallenged. Their photos revealed at least 90 Japanese warplanes clustered around the Thai capital.

On the morning of 20 December, the call came that 10 Japanese bombers were approaching Kunming from the south. They were Mitsubishi Ki-21s (Army Type 97), considered to be heavy bombers by the Japanese; the type was later nicknamed 'Sally' by the Allies, and was the AVG's most frequently-seen bomber. Four 'Panda Bears' Tomahawks led by Jack Newkirk scrambled immediately while all 16 'Adam & Eves' flew to an auxiliary airfield southeast of Kunming to await developments. Newkirk suffered a mechanical failure of both radio and guns and, enraged, had to turn back without slowing the Japanese. The 16 Tomahawks of the 'Adam & Eves' then belatedly launched, and intimidated the unescorted Japanese bombers into jettisoning their loads and turning back toward their base near Hanoi. In this initial engagement, the AVG pilots claimed four bombers. Ed Rector of the 'Panda Bears' went missing after downing one of the bombers but rang the next morning to say he was safe.



The first fighter adversary of the AVG was the Nakajima Ki-27 'Nate'. This fixed-gear monoplane was highly manoeuvrable but lightly armed, and not really a match for the Hawk 81. This example was captured in late 1942, after the 'Flying Tigers' had disbanded, and was evaluated at Kunming in Chinese markings.



After the first battles over Rangoon, the Japanese army moved a fighter sentai equipped with modern Ki-43 'Oscars' to Bangkok. This unit, the 64th Sentai, was to meet the AVG many times over the following months. This is a later aircraft, a Ki-43-III-ko captured in China in 1945.

Demons

For a time, three Curtiss CW-21B Demon pursuit ships were in the hands of 'Flying Tigers' pilot Erik Shilling at Mingaladon. These fighters had been brought into China to serve as prototypes for an indigenous production run that was cut short by Japanese bombing. The CW-21B was a good high-altitude ship but had feeble armament. It hardly mattered. In a fiasco that infuriated Chennault, Shilling took all three CW-21Bs on a cross-country ferry flight that resulted in all three aircraft crashing and pilot Lacy Mangleburg losing his life. The intention had been, simply, to ferry the Demons to Kunming. Instead, the AVG was 'out' three radial-engined fighters and a man was lost; Shilling remained in disfavour for some time.

To preserve the fiction that Siam (Thailand) had never been 'conquered', Thailand had succumbed to Japanese demands and signed a treaty allowing the Japanese to use Thai bases to launch attacks on Burma, including beleaguered Rangoon. The 'Flying Tigers' found themselves fighting Japanese Army Aviation (JAA), which

AVG Hawks

'First Pursuit'
The 1st Squadron adopted an insignia depicting stick figures of Adam and Eve on an apple engaged in the 'first pursuit' in history. The squadron itself was nicknamed the 'Adam and Eves'. This aircraft was strafed and destroyed at Magwe on 21 March 1942. Aircraft belonging to the 1st Squadron were further identified by the white fuselage band and tactical numbers between 1 and 33.

'Panda Bears'
Few aircraft of the 2nd Squadron, the 'Panda Bears', wore a representation of their nickname. One exception was '38' (2nd Squadron aircraft were numbered from 34-66, although this system eventually broke down), flown by Henry Geselbracht who added a personal black panther insignia. Aircraft of the 'Panda Bears' wore a blue fuselage band.

had gained experience from its wars in Manchuria and China. The Japanese pilots were seasoned veterans with high morale and good discipline. Later, the Japanese drew units from Malaya and the Philippines where they had triumphed over British and American forces. The 'Flying Tigers' never faced the Japanese navy – or its vaunted Zero fighter – because, as AVG pilot Charles D. (Charlie) Mott put it, Burma "was a Japanese army show."

Defence of Burma

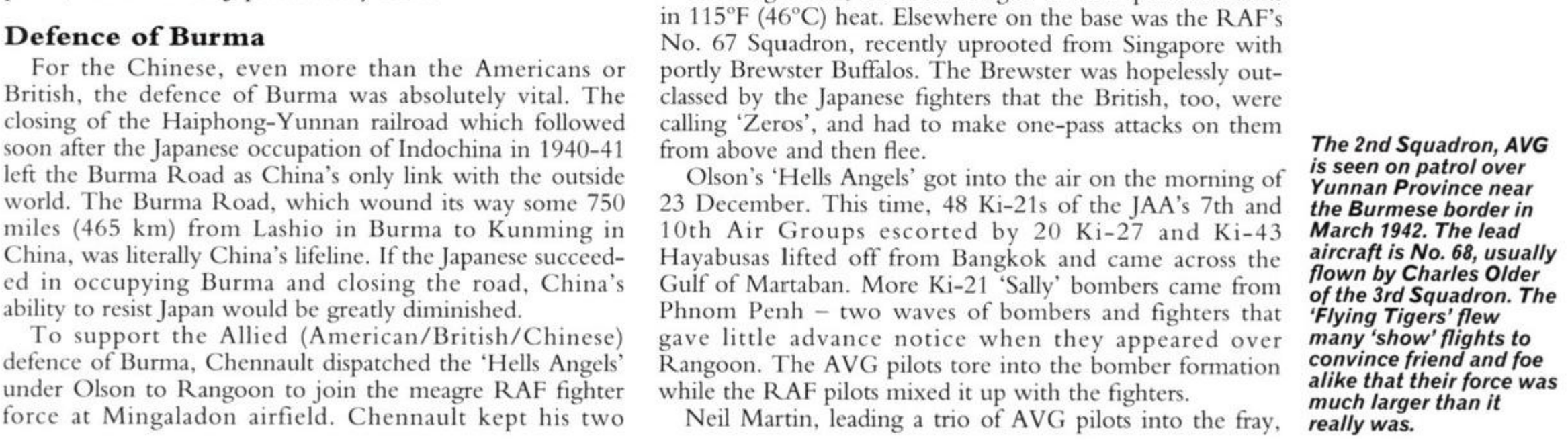
For the Chinese, even more than the Americans or British, the defence of Burma was absolutely vital. The closing of the Haiphong-Yunnan railroad which followed soon after the Japanese occupation of Indochina in 1940-41 left the Burma Road as China's only link with the outside world. The Burma Road, which wound its way some 750 miles (465 km) from Lashio in Burma to Kunming in China, was literally China's lifeline. If the Japanese succeeded in occupying Burma and closing the road, China's ability to resist Japan would be greatly diminished.

To support the Allied (American/British/Chinese) defence of Burma, Chennault dispatched the 'Hells Angels' under Olson to Rangoon to join the meagre RAF fighter force at Mingaladon airfield. Chennault kept his two remaining squadrons in Kunming for the defence of China. The defence of Rangoon was the first big job taken on by the 'Flying Tigers', and from this point onward Chennault always followed a strategy of maintaining a reserve at all times. On the other side, the Imperial Japanese 15th Army under Lieutenant General Shojiro Iida was preparing to invade Burma by driving at Moulmein from Thailand.

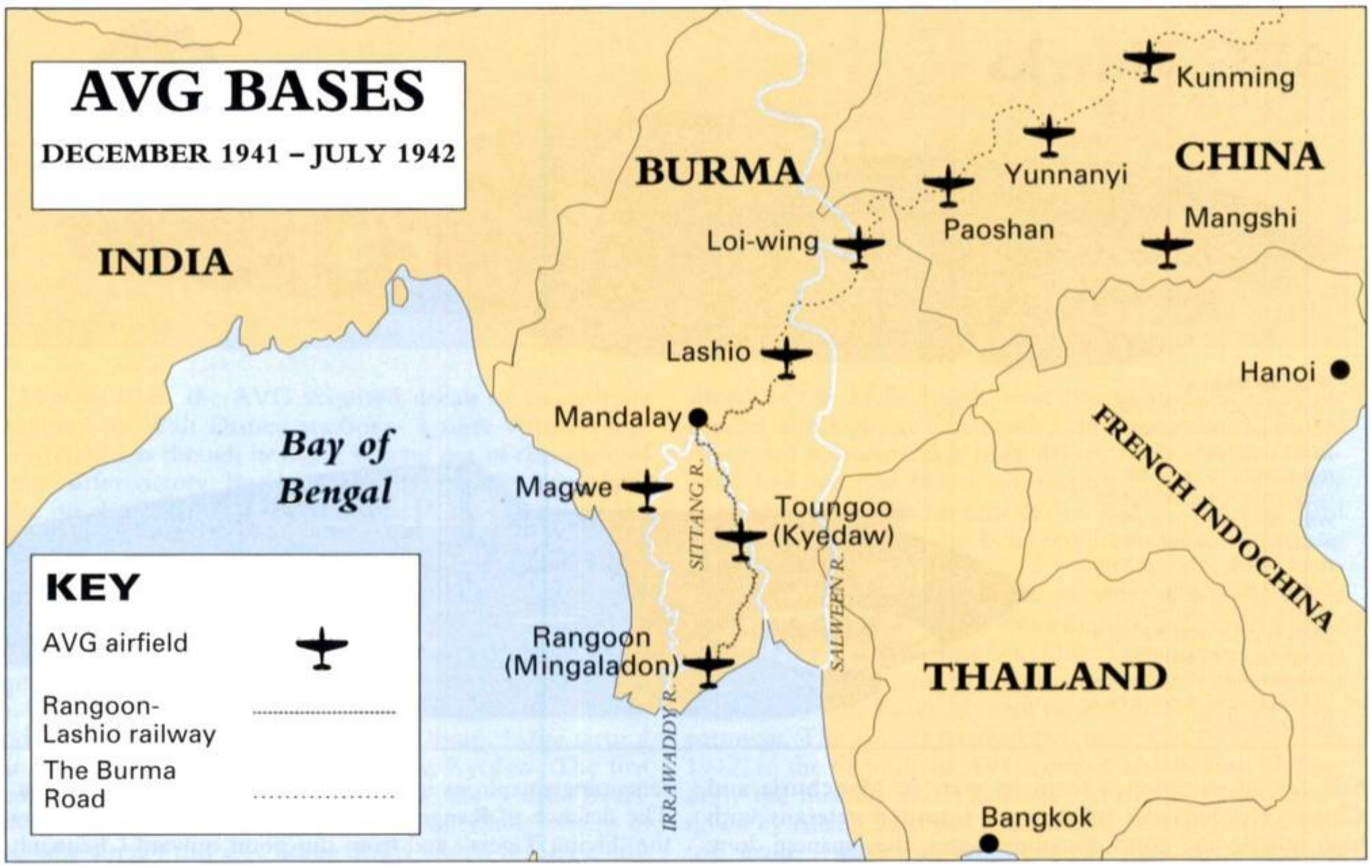
At Mingaladon, the 'Hells Angels' lived in primitive tents in 115°F (46°C) heat. Elsewhere on the base was the RAF's No. 67 Squadron, recently uprooted from Singapore with portly Brewster Buffalos. The Brewster was hopelessly outclassed by the Japanese fighters that the British, too, were calling 'Zeros', and had to make one-pass attacks on them from above and then flee.

Olson's 'Hells Angels' got into the air on the morning of 23 December. This time, 48 Ki-21s of the JAA's 7th and 10th Air Groups escorted by 20 Ki-27 and Ki-43 Hayabusas lifted off from Bangkok and came across the Gulf of Martaban. More Ki-21 'Sally' bombers came from Phnom Penh – two waves of bombers and fighters that gave little advance notice when they appeared over Rangoon. The AVG pilots tore into the bomber formation while the RAF pilots mixed it up with the fighters.

Neil Martin, leading a trio of AVG pilots into the fray,



The 2nd Squadron, AVG is seen on patrol over Yunnan Province near the Burmese border in March 1942. The lead aircraft is No. 68, usually flown by Charles Older of the 3rd Squadron. The 'Flying Tigers' flew many 'show' flights to convince friend and foe alike that their force was much larger than it really was.



inexplicably flew into a barrage of defensive gunfire from the bombers and flipped up, presenting the vulnerable belly of his Tomahawk to their massed gunfire. The Ki-21 gunners ripped his aircraft apart and he went down in flames.

Ken Jernsted and Charles Older each blew a Ki-21 out of the sky but moments later Henry ('Hank') Gilbert, at 21 the youngest 'Flying Tiger', fell in a barrage of fire from the Ki-21 turrets. Moments later, Paul Green's Tomahawk was struck by gunfire and he bailed out. It was over almost as quickly as it had begun, a short-lived but furious battle in which AVG pilots were credited with 10 bombers and one fighter while losing four Tomahawks and two pilots. The RAF claimed three fighters but lost five Brewster Buffalos, along with all of their pilots.

Christmas Day battle

With the fate of Rangoon hanging in the balance, Christmas Day 1941 saw an air battle that has been built up in legend. 'Oley' Olson's 'Hells Angels' had 13 Hawks, nearly as large a force as a single AVG squadron ever mustered at once. At about noon, Tomahawks and RAF Buffaloes took to the skies. They faced 60 Japanese bombers approaching in Vee formation, escorted by at least 20 fighters.

Away from Kunming, the 'Flying Tigers' had to put up with the most basic of conditions. For the aircraft, it was dust in the summer and mud in the winter. For the crews, it was poor housing, rodents, insects and illness most of the time.

There were aircraft recognition problems on both sides. A Japanese pilot reported fighting 'Spitfires' (the Tomahawks) while the AVG's Parker Dupouy said he had engaged a Messerschmitt Bf 109; in fact, there were no Spitfires nor anything resembling a Bf 109 for thousands of miles.

The Christmas battle was described by Robert P. ('Duke') Hedman of the AVG's 3rd squadron:

"'Bandits at 11 o'clock!' We form into elements (two-ships). Your throat sometimes gets dry at times like this. You're tucked in tight, so tight that the wingtip vortex from number two keeps spilling your wing under and you have to hold right aileron to keep the ship straight.

"Our first pass is into the bomber formation from the front and slightly to the left. [Flight leader George B.] McMillan instructs us not to fire too soon. The rate of closure is terrific. At 200 yd (182 m) I begin shooting at the bomber that's closest to me. I can feel return fire slamming into the cockpit around me."

And, on a later pass: "By now I'm close enough to see the face of the rear gunner. I pour a good two-second burst into the tail and rear gun pit, before dishing out into a dive with another fighter coming after me. No use turning with the fighter. He's too nimble. Diving is the only answer. The fighter breaks away and climbs to defend his flock, and I again take the offensive [against the bombers]."

The AVG will forever be associated with the sharkmouths on their P-40s, a device borrowed from No. 112 Squadron, RAF. The Japanese were bemused by the concept; a contemporary newspaper pondered the "... peculiar design ..." understandable on a submarine, perhaps, "... but on a plane ...?"

Charles Older's No. 68 heads this line-up of Tomahawks of the 3rd Squadron. 'Chuck' Older was credited with 10 kills with the AVG and another eight while flying with the 23rd FG later in the war. Post-war, he became a Los Angeles Superior Court Judge, trying the case of Charles Manson, among others.

And still later, Hedman battled an aircraft he identified as a Zero: "I ... look over the top of the canopy and see a Type 0 fighter chasing a P-40. I'm behind him slightly and well above, still inverted. I pull the stick back and dive down. When I roll out of it, it puts me in a good seven o'clock position. I open up. He rolls left and up, right into my line of fire. His canopy disintegrates into a ball of orange flame."

After chasing a fighter off the tail of 'R.T.' Smith, Hedman came under attack from a Ki-43. He carried out a half-roll and dived to escape in a cloud bank, then landed at an auxiliary airfield. Another Tomahawk pilot, Eddie Overend, suffered hits and made a belly-landing 30 miles (46 km) east of Rangoon. At the end of the day, 'Flying Tigers' were scattered all over the area.

The 'Flying Tigers' claimed 24 Japanese aircraft on Christmas Day according to some records, 28 according to others. Actual Japanese losses may have been 10, not counting as many as eight Japanese aircraft that went down at sea after the engagement. Most of the Tomahawks sustained damage, but none of the American pilots was lost in battle. Parker Dupouy lost 4 ft (1.22 m) of his wing to a Hayabusa (which he called a Zero) in a mid-air collision. George McMillan downed two bombers, flew into protracted gunfire from the dorsal turret of a third, and saw his windshield and oil coolers tear away in front of his face. His engine quit but McMillan stayed with the Tomahawk in a long, uncomfortable glide. He made a wheels-up landing in the jungle and in due course returned to Mingaladon via mule, river barge, and oxcart. RAF Buffaloes were credited with eight bombers but lost five of their fighters, along with the pilots. Most of No. 67 Squadron's Buffalos were destroyed in the air or on the ground, effectively ending this RAF unit's role as an capable fighting force.

Claim and counterclaim

The outcome of the Christmas battle was exaggerated on all sides. For years, it was reported that the 3rd Squadron's 'Duke' Hedman scored five aerial victories on 25 December, making him the first American ace of the war. In fact, even AVG records credit Hedman with 4.83 aerial victories.

The Christmas Day air battle over Rangoon marked the first time the Japanese understood that they faced genuine opposition. In a post-war interview in Japan, a Hayabusa pilot, Ichino Hashi, said that the Emperor's forces had expected to "ride over the top of" anyone who tried to challenge them, and that, "We knew about [the AVG] but did not expect them to stand in our way." The Japanese were impressed by the doggedness and persistence of the AVG pilots. Largely unchallenged in their past conquests, they now took full measure of the Tomahawk and the men flying it.

The Japanese also adopted deceptive tactics. On 28 December, they sent a decoy strike force that drew 10 'Hells Angels' Tomahawks into the air and away from Rangoon. Only when the Tomahawks needed to refuel did a second strike force of 10 Ki-21 bombers bore towards Mingaladon. Now, only four Tomahawks could get into the air, accompanied by a dozen Buffalos. The bombers broke through the fighter screen, made their run-in at 3,000 ft (916 m) with little ground fire to oppose them, and unleashed their bombloads on hangars, service buildings – and aircraft being refuelled and rearmed.

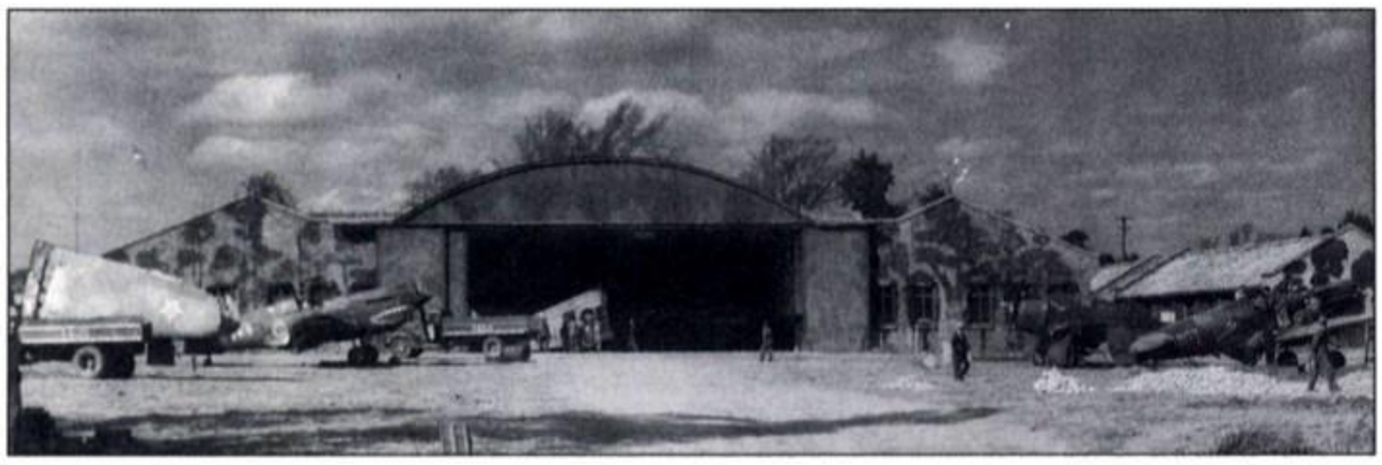
Relief at Rangoon

At the end of December the 'Hells Angels' left Rangoon, to be replaced by the 2nd Squadron, the 'Panda Bears'. The latter's leader, Jack Newkirk, brought 17 Tomahawks into Mingaladon on 30 December. Newkirk decided not to wait for the Japanese to come to him, and for several days the 'Panda Bears' raided airfields in Thailand.

After being strafed by the AVG five times, the Japanese struck back. A formation of 23 Ki-27 fighters led the way at mid-morning on 4 January 1942, intending to shoot up Mingaladon. This was the kick-off of a three-day campaign at maximum strength by the Japanese, who were to pay dearly for the effort. Two Tomahawks got aloft to intercept them. 'Tex' Hill and Frank Lawlor kept the bombers busy until more Tomahawks with four or five RAF fighters joined in. The Japanese fighter was very manoeuvrable but was outgunned by the Tomahawks. The AVG pilots claimed seven kills, four of them by Frank Lawlor.

Perhaps the most famous alumni of the 'Flying Tigers' was Gregory 'Pappy' Boyington. Seen later in the war when CO of VMF-214 'Black Sheep', Boyington was officially credited with two air-to-air victories with the AVG and 2.5 ground kills. His final score was 24 aerial victories.

'Flying Tigers'



Above and right: AVG aircraft needing major repair were taken to the CAMCO-operated overhaul plant at Loi-wing. Servicing was conducted by Chinese personnel and was of an excellent standard. A number of the Chinese mechanics joined the airline formed by ex-AVG members post-war; Flying Tiger Lines. The interior of the plant, which was taken over by the USAAF after the dissolution of the AVG, was decorated in places with Nationalist political slogans.

Although the official USAF caption to this picture of 23rd Fighter Group pilots claims that they were all ex-AVG, in fact only Major David Hill, second from left (then 23rd FG CO), had flown with the original 'Flying Tigers'. Such inaccuracies, the adoption by the 23rd FG of a 'Flying Tiger' insignia and other paraphernalia all led to much post-war confusion as to who has the right to call themselves a 'Flying Tiger'. 'Tex' Hill was the top scorer of the 2nd Squadron with 10.25 confirmed victories. He was one of the five AVG pilots to transfer to the USAAF in July 1942.

The Tomahawk pilots scarcely had time to get back, refuel and rearm before the bombers came. Two formations of bombers, 19 in the first wave and 12 in the second, escorted by some 30 fighters, appeared over Rangoon shortly after noon. AVG Tomahawks made slashing passes at the bombers and flamed them one after the other. Six bombers were claimed, along with four of the escorting fighters, while four Tomahawks and one pilot were lost.

The New Year ushered in a dark era for the Allies in Asia, and the Japanese continued the drive on Burma they had begun in December. The 'Adam & Eves' and 'Panda Bears' continued to defend Rangoon, together with RAF pilots who were bolstered by the arrival of a handful of Hawker Hurricanes.

In the second major air battle, on 4 January, Gil Bright went down in a Tomahawk for his second time and set some kind of a record for survival. Bullets from a Ki-27 'Nate' fighter tore into Bright's cowling and he dove away with his engine on fire. Perhaps mindful of his earlier bail-out – where he had been shot from his Tomahawk like a cork from a bottle – Bright stubbornly rode this Tomahawk down to a belly-landing in a dry paddy field near the railroad tracks. Bright suffered burns to his face when he shoved back the canopy. He stumbled out and was fired upon by his own 0.50-in (12.7-mm) guns, torched off by the fire. Bright staggered to a nearby building, which he found to be a railroad station. Ammunition popping off in the background, smoke in his nostrils, Bright reached Mingaladon by telephone and was told he could return to safety by climbing aboard the next train.

Taken prisoner

The Japanese pressed on with their three-day campaign against Rangoon, sending bombers and fighters again and again. The Tomahawks rose to meet them each time and as many as 25 Japanese warplanes tumbled from the sky. On 8 January 1942, the aggressive 'Panda Bears' went on another strafing expedition to Meshot and flight leader Charles Mott remembered how he became one of only four AVG men to be taken prisoner:

"Photos came in that showed Japanese aircraft positioned at Meshot airfield near the Thai border, within easy range of our P-40s. This field was being used by Japanese fighters which had been giving us quite a bit of trouble, nipping over the border, shooting up the field at Moulmein (where there was nothing except a few drums of refuelling gasoline), and high-tailing it back across the border, declining a fight over our own territory. We decided on a four-plane attack on 8 January [1942] at noon, when the enemy presumably had their faces in mess buckets. Two aircraft would fly high cover while the other two strafed the field.

"In my run I saw a large working party, possibly Thais (Thailand was not our enemy), at the end of the runway. So I buzzed them but fired my two 0.50-in and four 0.30-in guns into the aircraft and ops tents along the flight line. I could see my hits, and when I turned back after pull-up, fires were burning nicely.

"Next, I made runs on dispersed aircraft, during which I heard two hits on the fuselage of my P-40. I continued strafing and then climbed for another pass. In the run, about 30 ft (9.15 m) above the ground, just as I was pressing the trigger, I was hit again, hard. The engine quit cold. I converted altitude to airspeed and tried everything to get the engine started again, but to no avail. Smoke bloomed from my engine as I bailed out, got one swing of the chute, and slammed into a giant-sized jungle tree. In extricating myself, I fell about 20 ft (6.1 m) and hit hard." Badly injured near the spot where his Tomahawk burned – "the ammo pans cooked off, exploding with sharp pops" – Mott was seized by a Japanese soldier who jammed a bayonet into his buttocks.

On the first sorties, Newkirk, 'Tex' Hill and Jim Howard were credited with downing fighters, probably Ki-27s. Jim Howard shot up four Japanese fighters on the ground, which counted as kills under Chennault's rules, so Howard was considered to be an ace.

Under pressure

On 12 January 1942, Japan's Lieutenant General Iida began the ground assault from Thailand into Burma, intending first to cut off Rangoon from Kunming and in due course to seize Moulmein and then the Burmese capital. Now, many of the Japanese bombing raids came at night when there was no way to oppose them in the air. The AVG Tomahawks, desperately short on spare parts, kept up their efforts when the enemy could be seen by daylight. The AVG moved some aircraft to Loi-Wing, a small town in a valley just inside the Chinese border. The Japanese proceeded to push against and wear down the defenders of Burma; the handwriting was on the wall.

At Mingaladon, the Japanese raids took a physical and psychological toll. Every hangar was burned out and blackened, and hardly a building had a standing wall left. The men bedded down the Tomahawks in surrounding paddy fields and the pilots were quartered in Rangoon. The 'Panda Bears' withdrew to Kunming to gain respite from the war. At Mingaladon on 7 February 1942, Robert 'Sandy' Sandell, squadron commander of the 'Adam & Eves', took a repaired Tomahawk aloft, wrung it out, and ended with a barrel roll over the airport from which he was unable to recover. Sandell and his aircraft went in. There was no fire, just a dry, rending disintegration that plowed up a storm of dust. Command of the 1st Squadron passed to

Bob Neale.

In February, the AVG even flew escort missions to accompany RAF Blenheim bombers attacking Japanese targets. Small forays were also mounted in which flights of Tomahawks ventured into Thailand to attack Japanese aerodromes.

By the end of February 1942, AVG pilots knew that it was just a matter of time before Rangoon fell. The Japanese pushed British forces back to the Sittang River, and in the Battle of Sittang (18-23 February) inflicted a major ground defeat that seemed the beginning of the end. Despite the valiant efforts of the little fighter force at Mingaladon, bombs still rained on the city. During night missions, the bombers were unopposed. On 25 February the Japanese returned by day. The AVG was able to get only nine Tomahawks into the air, while the RAF mounted six Hurricanes. The little force tore into the big bomber and fighter formations and the AVG scored another big victory. The Tomahawk pilots claimed 24 Ki-27 fighters. The Japanese returned the following day, not once but twice. AVG pilots claimed 16 victories in the morning engagement and five more in the afternoon – a two-day total of 46 Japanese aircraft blasted from the sky.

As all men have done in all wars, without exception, Americans and Japanese were claiming greater success than they were actually achieving. In seven months of existence, AVG pilots claimed 268 aerial victories. Decades later, author Daniel Ford – with access to Japanese war records – put the actual figure at around 115. Debate still rages over aerial victory claims, generating more heat than light, but any argument about the numbers is certain to miss the point. The Japanese military machine had ground its way over every opponent in its path, sometimes without opposition, other times in the face of serious resistance – as when Soviet-piloted Polikarpov I-15bis and I-16 biplane fighters joined the defence of Nanking in late 1937 – but they never came up against anything quite like the 'Flying Tigers'. In Manchuria, in China, at Hong Kong, at Singapore, the Japanese sometimes faced stubborn adversaries, but in the 'Flying Tigers' they met men who fought with unprecedented determination. In the battle for Burma, the tiny fighter force arrayed against the Japanese onslaught was the most effective resistance the Emperor's forces ever encountered. The 'Flying Tigers' drew blood and bought time.

Fall of Burma

The 'Adam & Eves' were the last fighter pilots to evacuate when Rangoon finally fell to the Japanese on 8 March 1942. Bob Neale and another man were the last pilots out. The situation in Asia and the Pacific was now at its grimmest. American forces had been pushed off Java, the situation in the Philippines and on the Malay peninsula was deteriorating – but the 'Flying Tigers' were creating a legend that brightened spirits on the home front. Pilots began to read about themselves in newspapers and clippings sent to them by their families.

The Allies looked for help to Chiang Kai-shek of China's Kuomintang, or Nationalist, forces. Chiang made two army corps available to the US commander in China, Lieutenant General Joseph Stilwell, and these troops poured down along the Burma Road, hoping to bottle up the Japanese in southern Burma while allowing the Allies to move supplies and equipment in the north. In March 1942, clustered at Kunming, the AVG had weary pilots, many of whom were ill, and fewer aircraft than ever. Then, word came that 30-odd ex-US Army Curtiss P-40E Kittyhawks were on the way. A number of pilots had been sent to the Middle East to ferry them back to what was being called the China-Burma-India (CBI) theatre.

The P-40E Kittyhawk I, or Curtiss Hawk 87B-2, was powered by an Allison V-1710-39/F3R with a one-stage one-speed supercharger rated at 1,040 hp (775 kW) at take-off. Some Curtiss documents refer to the aircraft as the 'Kittihawk', although the name clearly was inspired by the name of the city near the Wright Brothers' first powered flight in 1903 – Kitty Hawk, North Carolina. First in a new series of Hawks that were heavier and slightly slower than their predecessors, the P-40Es were armed with six 0.50-in (12.7-mm) wing machine-guns. The E model retained the 'short' fuselage associated with the early P-40 series, had revised armour, and was not equipped with wing bomb racks. The Kittyhawk was readily distinguished from the Tomahawk by its new nose contours, including a much deeper air scoop for Prestone and oil coolers, and a larger Curtiss-Wright three-bladed propeller.

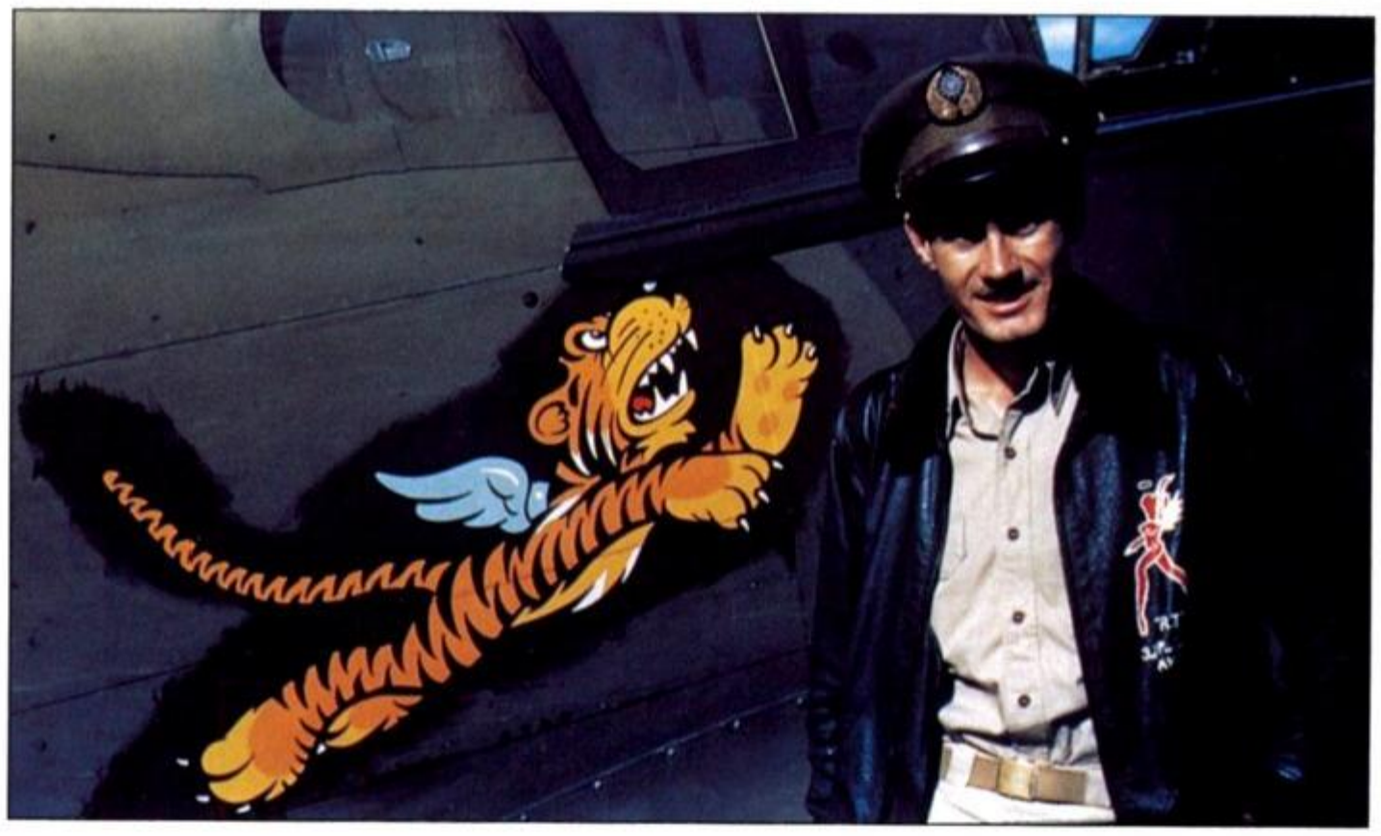
Robert Tharp ('R.T.') Smith is one of the best-known 'Flying Tigers' pilots, in part due to his autobiography (Tale of a Tiger, 1986) and the colour photographs he took while with the AVG. His official score was 8.9 kills, including two 'Oscars' and two 'Sallys' destroyed and two damaged in the great air battle of 25 December 1941. Here he is seen in aircraft No. 40. His usually-assigned aircraft was No. 77.

Army recruits

While the AVG was receiving new aircraft, plans were afoot to drape uniforms over its pilots and mechanics and impress them into the Army. From the moment the US entered World War II, days before the AVG's first combat mission, it was understood that the 'Flying Tigers' would be impressed into military service. Some had been officers when they joined the AVG – Gregory 'Pappy' Boyington held a 'regular' commission as a first lieutenant in the Marine Corps – but their flamboyant behaviour in Burma and China was not the stuff of military public relations: quite openly, AVG pilots drank, gambled and chased women. Chennault was well aware of the plans to bring the AVG into uniform; not having got higher than captain in the Army Air Corps, he was often called 'colonel' or 'general' in China and wanted to be a real brigadier general. Most Tomahawk pilots thought little about it as they continued fighting after the fall of Rangoon.

At this point the pilots were handed a new mission that they did not relish: they were assigned to fly ground

Wearing a Chinese air force cap badge and a variation of the 'Hells Angel' insignia on his jacket, 'R.T.' Smith stands by the 'Flying Tiger' on his P-40. The dark coloration around the tiger is the result of a varnish overcoat applied to keep the decal from lifting.



Chuck Older and 'R.T.' Smith are seen in their best dress uniforms for a medal presentation at Kunming. The decorations were the Chinese Air Force Medal and Order of the Cloud Banner. Older had each of these with Bars. Note the AVG pins on Older and Smith's blouses and the pinwheel design on the wheel of the Hawk behind them, a marking common in the 3rd Squadron.

Above right: This view of 'R.T.' Smith's aircraft (No. 77) shows his scoreboard and one of the many variations of the angel badge designed by crew chief Stan Regis. The light-coloured patch inboard of the guns was a repair patch over damage caused by debris from a damaged Japanese bomber.

support for Chinese troops. While they recognised the importance of the ground troops making an orderly retreat, they knew the dangers of getting down on the deck and strafing while every weapon that fired would be trained on them the entire time. Even worse, next came 'morale missions' that pilots despised. It had been suggested that Tomahawks fly over the retreating Chinese troops just so the soldiers could see the aircraft. After protests from pilots, Chennault ended these useless sorties.

Tigers to Loi-wing

By late March 1942, the airfield at Magwe had become untenable and the men moved on to Loi-wing on the China-Burma border. Most AVG pilots were now based at Kunming and staged through bases like Loi-wing to strike at the Japanese. On 24 March 1942, Jack Newkirk led a number of his 'Panda Bears' to join a strafing attack with Bob Neale's 'Adam & Eves' on the aerodrome at Cheing-mai. En route to the rendezvous, Newkirk spotted an apparent Japanese convoy composed of trucks protected by armoured cars. Newkirk led the Tomahawks in the attack, and as he levelled off at about 50 ft (13 m) his Tomahawk took hits from an armoured car and he crashed in a sheet of flame. Newkirk had been an outstanding leader and ace of the 'Flying Tigers', credited with 10½ aerial victories.

Bob Neale's attack on Cheing-mai airfield was more successful. Neale apparently arrived over the Japanese airstrip in Thailand just as mechanics were checking over the Ki-27 and Ki-43 Hayabusa fighters of the 64th and 77th Sentais in preparation for the day's combat. Neale's pilots caught a large number of Japanese fighters on the ground, and were credited with destroying 15 of them. AVG pilot William D. McGarry suffered an engine failure on the way home, parachuted to safety, and was captured 28 days later.

24 March was also the day the Japanese seized Kyedaw airfield. Japanese troops poured into central Burma. The fall of Toungoo was followed by the loss of Magwe and the vital oilfields at Yenangyuang. The AVG was making a stand against no fewer than five JAA sentais – the 1st, 11th, 50th, 64th, and 77th. The Americans probably never knew that Japan's warriors were frustrated at encountering such resistance, and confused about the number and capabilities of the newly-arrived P-40E. Neither side really understood it, but there was relatively little difference in the performance of fighters on both sides.

At Loi-wing, Oley Olson's 'Hells Angels' (3rd Squadron) had a sign calling themselves 'Jap Exterminators'. They were not pleased about the way they were being treated as their side's fortunes in the war continued to erode. The disagreement over the 'morale missions' was not handled well, in their view, and they failed to understand why more supplies were not reaching them. On 23 April, a rebellion of sorts occurred when 23 pilots turned in their resignations – although nothing in their hiring contract said they could quit – over a variety of issues, including escort missions which the AVG pilots believed were useless. Fortunately, Chennault worked out with Chiang Kai-shek an arrangement that enabled the men to return to intercept missions. Here, they believed, they had an excellent chance to inflict further damage on the Japanese steamroller.

During the last days at Loi-wing the 'Flying Tigers' saw sharp action. 'Tex' Hill led a fighter sweep of 17 Tomahawks – a massive force by AVG standards – when he spotted a formation of bombers west of Hsipaw heading for Loi-wing. As they closed in, the AVG pilots found that the rear of the Japanese formation teemed with fighters (Hayabusas). Fights broke out all over the area and Tomahawks were credited with 13 kills. 'Chuck' Older and 'Duke' Hedman encountered a Japanese pilot who knew every trick in the book. Their close-quarters duel went on for 20 minutes before Hedman finally put the finishing touches on him while he was attempting to latch on to Older.

From Loi-wing, the AVG moved to Paoshan and

Right: Two informal shots of 3rd Squadron pilots at Yunnanyi. Once again note the Navy/Marine-style G-1 jackets (with fur collars) worn by most of those here. The first picture at right shows (standing, left-right): Eric Schilling and Oley' Olson; (seated left-right): 'R.T.' Smith, Ken Jernstedt, Bob Prescott, Chauncey 'Link' Laughlin, and Bill Reed. The photo at right shows the same group with Shilling exchanged for Tom Haywood.

The first P-40E Kittyhawks for the AVG began to arrive in China in late March 1942. A gradually-increasing number of P-40Es served alongside the Hawk 81s up to and beyond the dissolution of the AVG. One important difference with these aircraft was that they were factory-equipped for carriage of drop tanks and bombs. They were heavily involved in the battle of the Salween Gorge in May 1942.

eventually to Kunming. Air combat and Japanese bombs had taken a great toll on the Tomahawks and Kittyhawks of the AVG. At Paoshan they again came under bombing attacks. In the evacuation of Loi-wing on 1 May 1942, the 'Flying Tigers' had to destroy two dozen Tomahawks that were being repaired and could not be trucked out. The devastating bombing of Paoshan made the latter air base untenable, and it was time to move once more.

On 12 May 1942, AVG pilots mounted a long-range mission that took them to a refuelling stop near the Indochina border. These 'Flying Tigers' followed the Red River southeast and attacked Hanoi's Gia Lam airfield. More than 400 miles (643 km) from home, they wiped out as many as 16 Japanese aircraft but soon found themselves immersed in gunfire. AVG pilot John Donovan's fighter was hit and went down during a strafing run.

Repelling the intruders

Throughout May and into June the Tigers flew mission after mission, bombing and strafing the oncoming Japanese. In June, the 'Adam & Eves' were assigned to the new airfield at Kweilin. The Japanese had already begun bombing it and Bob Neale's squadron decided to oppose the aerial onslaught. The alarm came on 12 June, and when the Curtiss pursuits went aloft they found a force of 10 bombers escorted by about a dozen Ki-27 fighters. The AVG pilots claimed nine victories plus four probables.

Chennault's job, now, was to mount an air defence that would minimise the impact of Japanese air raids on Kunming and Chungking (Chongqing). Rather than prepare for a set-piece battle, he uprooted most of the AVG and moved it east, to bases along a line from Hengyang to Kweilin. The 'Hells Angels' of the 3rd Squadron remained at Kunming with 10 flyable aircraft, while four fighters of the 'Panda Bears' (2nd Squadron) stayed on at Chungking.

Petrol was plentiful at both cities, and the AVG flyers appeared overhead as much as they could to give the impression of a larger force. The 'Adam & Eves' (1st Squadron) and the bulk of the 'Panda Bears' were already gone, to Kweilin (Guilin) and Hengyang, respectively.

Kweilin was the target on 13 June 1942 when nine Ki-21 bombers approached, accompanied by four Ki-27 'Nates' and five new Kawasaki Ki-45 (Type 2) Toryu twin-engined fighters, later dubbed 'Nick' by the Allies. AVG pilot Bob Neale believed the new fighter, which had a 37-mm cannon, was a variant of the Messerschmitt Bf 110 – by which, in fact, it had been inspired. Three flights of Tomahawks and Kittyhawks led by Neale, George Burgard, and Charlie Bond pounced on the Japanese from higher altitude. In the melee that followed, the AVG lost two aircraft (though their pilots survived) but claimed 11 Japanese warplanes shot down. One was a Ki-45 flown by a squadron leader.

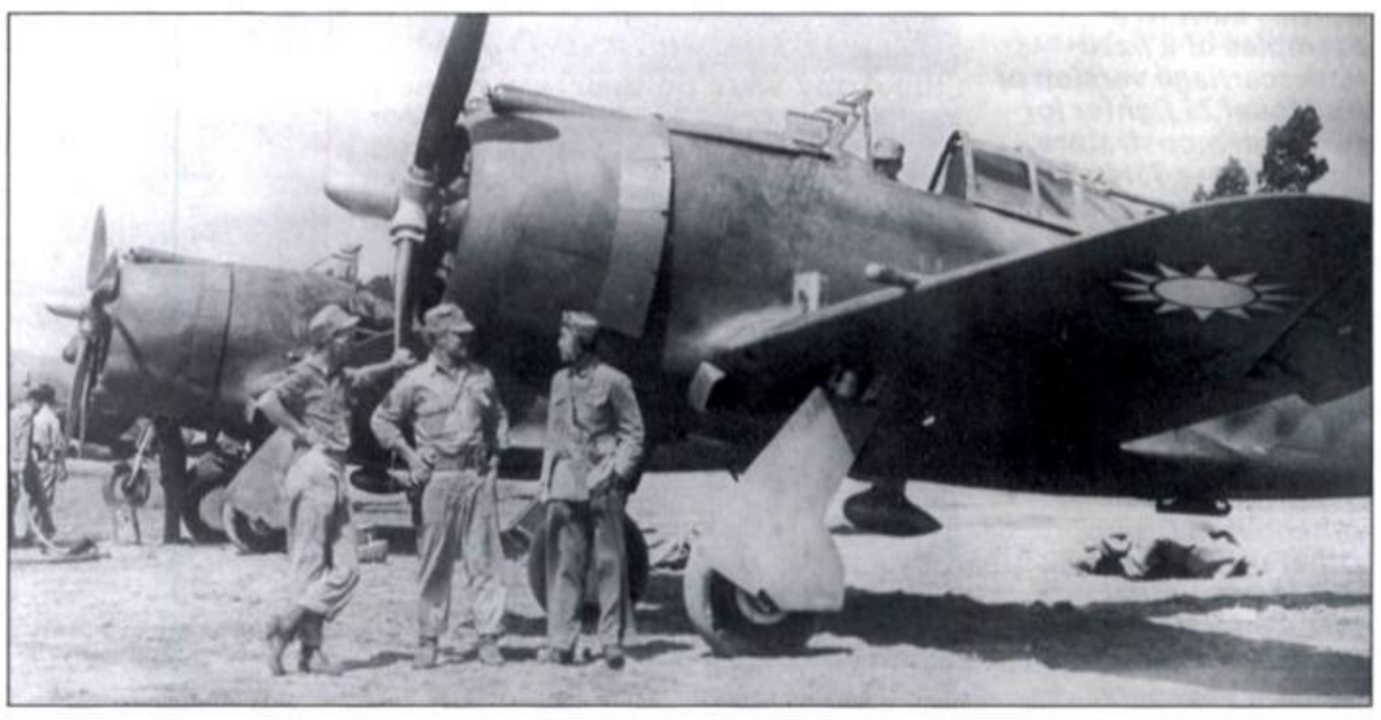
The June shutdown

Next came the monsoon season, inclement weather, and a shutdown of flying operations that came to the CBI theatre every year in the second week of June. Claire Chennault got his wish and accepted a commission as a brigadier general in the US Army Air Corps – although, to his consternation, he was made junior to another American air officer in China, Brigadier General Clayton Bissell. Under Chennault's direction, offers were made to all AVG pilots of military ranks ranging from first lieutenant to lieutenant colonel. Again to Chennault's chagrin, most of his pilots turned down the offers. They had been in the CBI for 10 months, in combat for seven. They were tired. And since many of them had come from the US Navy and Marine Corps, they did not desire commissions in the Army.

Chennault's long-standing efforts to create a bomber component of the AVG seemed, finally, to be near fruition. At the time of the Pearl Harbor attack, the US Army had

Below left: The monsoon rains were a hindrance to air operations on both sides, although the AVG's more northerly bases allowed them to operate over the Salween front while the Japanese fighters were grounded. When the rains came to western China, Chennault moved the AVG squadrons to the east to cover previously-undefended Chinese cities.

Below: At the end of the tenure of the AVG, a small number of Republic P-43 Lancers were borrowed from the Chinese air force for service with the AVG. Unpopular with the 'Flying Tigers' pilots, they were little flown. Some 108 of the 272 Lancers built served with the Chinese, often in single-aircraft units defending key targets.



Colonel Robert L. Scott made his way to Burma and China to join Chennault and arrived in time to fly a few unofficial missions with the 'Flying Tigers'. When the AVG was dissolved, he was appointed commander of the 23rd FG, with which he scored 10 confirmed victories and five probables.

Despite their increasing obsolescence, the Hawk 81s of the AVG soldiered on after the USAAF took over the AVG's assets. The slow rate of arrival of new aircraft (and the toughness of the Hawks) meant that the type lasted until December 1943. Of the 100 Tomahawks supplied to the AVG, only 18 serviceable aircraft (and a number under repair) were handed to their successors in July 1942.

seized 18 Lockheed Hudson bombers that had been destined for Chennault's force in China. Chennault was supposed to receive B-25 Mitchell bombers used by Colonel James Doolittle to attack Tokyo in April 1942, but none of the Mitchells reached him. In June, however, B-25s of the 11th Bomb Squadron began trickling in to Kunming, where Chennault 'appropriated' them for AVG use. Mitchells escorted by AVG Kittyhawks attacked docks, warehouses and shipping in the harbour at Hankow on 1 July. Other raids took place over the next two days as the calendar advanced toward American Independence Day, 4 July, the date that had been chosen for dismantling the AVG.

Dissolution

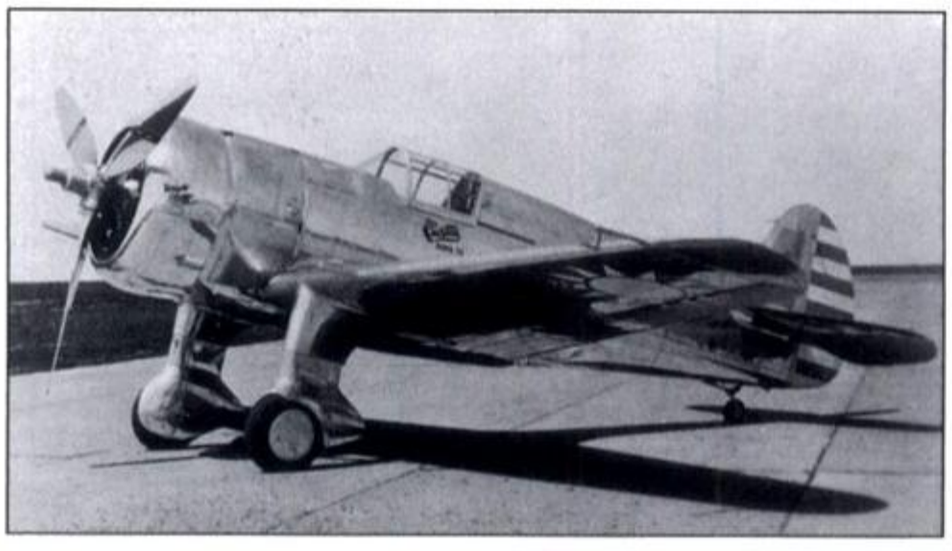
AVG members were to be inducted into the US Army Air Forces on 4 July 1942. The 'Flying Tigers' would become the 23rd Fighter Group, and the 'Adam & Eves', 'Panda Bears', and 'Hells Angels' would become the 74th, 75th and 76th Fighter Squadrons. Several candidates had been mooted to command the new fighter group, but Chennault liked an Air Transport Command pilot, Colonel Robert L. Scott Jr, who had been informally flying combat missions with AVG pilots. Preceded briefly in the group commander's slot by Bob Neale, Scott was not a 'Flying Tiger', but the men named to command his squadrons were – Frank Schiel Jr of the 74th, 'Tex' Hill of the 75th, and Ed Rector of the 76th. All were aces. All became majors. The 23rd FG took from the AVG 28 Tomahawks (18 of them airworthy) and 18 P-40E Kittyhawks (all but one flyable). The new fighter group also took over 11 Republic P-43 Lancers which had once been destined for the AVG: the P-43 had good high-altitude performance but was deemed a firetrap and was never accepted by pilots for routine fighter sorties.

A few AVG pilots, although unwilling to join the Army, grudgingly stayed on for two more weeks. On a 9 July 1942 sortie from Hengyang, Peter Wright racked up the 'Flying Tigers' final air-to-air victory when he shot down a twin-engined reconnaissance bomber. On 10 July, John Petach and Arnold Shamblin flew an air-to-ground sortie. Shamblin was lost in the action, apparently the AVG's final fatality. By mid-July, AVG members who had not joined the Army were on their way home via Kunming.

So, what did they accomplish? The 'Flying Tigers' top ace, Bob Neale, was credited with 15.50 aerial victories, closely followed by 'Tex' Hill with 12.25. Seven more pilots were double aces with 10 victories or more. Two pilots – Jim Hiward and Greg Boyington – used their AVG experience to earn the Medal of Honor in combat actions that took place after their AVG commitment. As previously noted, the AVG probably shot down 115 Japanese aircraft, not the 286 claimed, against a loss of 78 pursuit ships to all causes. But the numbers are misleading. Never equipped with more than 55 aircraft at a time, never properly equipped or supported – often at the wrong end of a nearly non-existent supply line – often "jerked around", as Charlie Mott put it, by politics of the war in Burma and China, the 'Flying Tigers' resisted Japan with incredible ferocity. When the AVG began its 30-week war, Tokyo news stories referred to Japan's military machine as 'invincible'; when it ended in July 1942, homebased newspapers routinely reported on the 'heroism' of Japanese pilots dying for the Emperor. Above all, the 'Flying Tigers' gave hope to the US population at a time when any boost to morale was profoundly needed. **Robert F. Dorr**

Claire Chennault was promoted to brigadier general (his Chinese air force rank) when the USAAF took over operations in China. He became the head of the China Air Task Force and, later, the 14th Air Force. He is seen here showing Lieutenant General 'Hap' Arnold, Chief of the USAAF, the P-40s of the 23rd FG, then only one of the units of his command.

At its own expense, Curtiss built two examples of a fixed-undercarriage version of its Model 75 fighter for use as demonstrators. One of these 75Hs, or 'Hawk 75s', was given to China in the hope of securing a contract for licensed manufacture. An almost identical Model 75Q demonstrator was presented to Chennault by Madame Chiang and used as his personal runabout in China. Other utility aircraft used by the AVG included a Beech 18, a Lockheed 12 and two Stinson Voyagers.



Legacy of the 'Flying Tigers'

After the dissolution of the AVG on 4 July 1942, most members of the 'Flying Tigers' made their way back to the US, and most of them wound up back in the services, a number being killed in other theatres later in the war. The 23rd FG adopted and adapted many of the insignia and traditions of the AVG and fought in China until the war's end. This led to some confusion in the public mind as to who could legitimately be called a 'Flying Tiger', especially since the 14th Air Force as a whole took the 'Flying Tigers' name for its official reunion group. The reputation of the 'Flying Tigers' grew to the extent that the name was deemed commercially suitable for a freight airline set up by ex-AVG members. With its origin as a civilian ('mercenary' in some eyes) group, official recognition of the work of the AVG and of the service records of those members who rejoined the military was slow in coming; many ex-members are still rankled at the way the government treated them for many years.

Below: In July 1945 Robert Prescott, a 1st Squadron 'ace', formed the National Skyway Freight Corporation, renamed Flying Tiger Line in 1947. Many ex-AVG pilots, like 'R.T.' Smith, joined the freight airline along with a number of AVG ground personnel. The airline flew C-47s, C-46s, DC-6s, Constellations, CL-44Ds (below), B707s, DC-8s and B747s. In 1989 Federal Express bought the airline for $850 million.

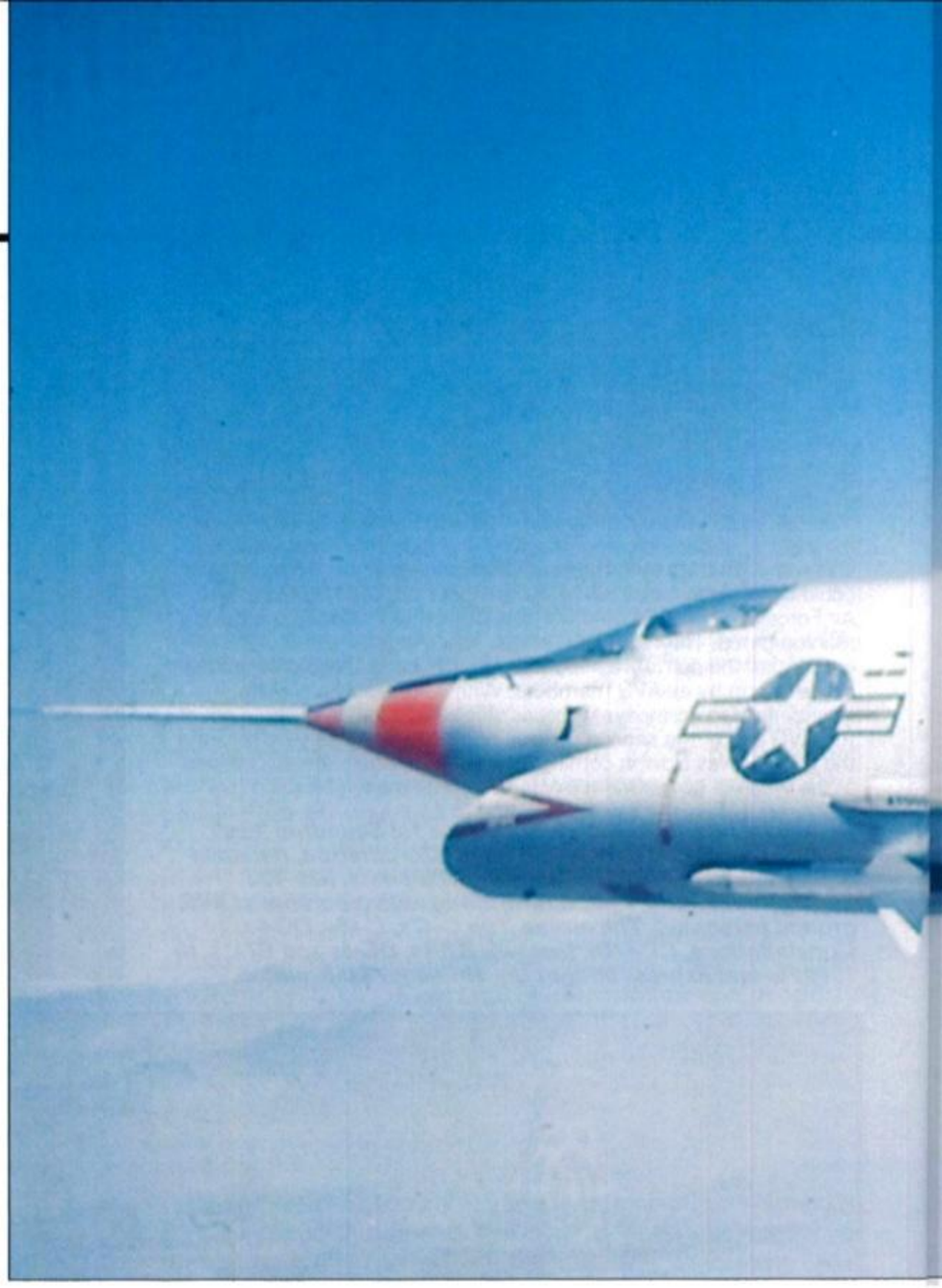
Above: The constituent squadrons of the AVG (the 1st, 2nd and 3rd Pursuit) became the 74th, 75th and 76th Fighter Squadrons, respectively. By the time this group portrait of the 74th FS was taken on 1 February 1943, there were no 'Flying Tigers' left in the unit, their first leader, Frank Schiel, having been killed in a flying accident.

Left: The 23rd FG was deactivated upon its return from China to the US in early 1946 and went through a cycle of reactivation and disbandment for many years, flying F-86s, F-89s and F-102s, among other types. In 1980, the 23rd TFW, as it had by then become, received the Fairchild A-10 Thunderbolt and revived the famous sharkmouths. The 74th FS 'Flying Tigers' of today's 23rd Wing operates with the 75th FS 'Tiger Sharks' (seen here) at Pope AFB, North Carolina.

Right and below: Pope AFB, North Carolina shares part of the extensive Fort Bragg military complex with a number of units belonging to US Army Aviation, including the 1st and 3rd Battalions of the 229th Aviation Brigade. The 3rd Battalion styles itself the 'Hell's Angels' and wears the 'Flying Tiger' insignia and sharksmouth made famous by the American Volunteer Group, although a direct connection between the units is fairly tenuous.

Vought XF8U-3 Crusader III

What might have been...



Aviation history is littered with excellent aircraft which should have become true classics, but by unfortunate circumstance remained as prototypes only. None was better than Vought's follow-on to its superb Crusader. Unfortunately, it was produced at the same time as McDonnell was creating the F4H Phantom.

By 1955, with much of the experimentation and knowledge of captured German research assimilated and incorporated into many of the world's air forces, a unique argument was raging in the United States. Main points of contention revolved around two important aspects of tactical jet aircraft. The first involved the need for two crewmen, as opposed to the more traditional single aviator, the fighter pilot who did everything – fly, navigate, and fight. The second consideration focused on the use of missiles instead of a fixed-gun armament. The two areas were linked because if future fighter aircraft were to be armed solely with missiles, then it would take a specialist – another crewman – to operate the system, while the pilot concentrated on flying the aircraft. Things were getting too complicated. Two pairs of eyes were also better than one in a dogfight.

Sandwiched between these main points was the fact that fighter pilots wanted more speed in the improved performance of any new fighter. "Excess thrust is what fighters fly on," observed former Vought chief test pilot, John Konrad.

The Air Force's F-105 Thunderchief and ultimately abortive F-107 – a development of the F-100 – were attempts to provide the desired increase in speed. The Navy had its designs, and there were other areas as well. Although single-seaters would probably be lighter, new fighters would probably use two engines, making the aircraft heavier, but providing an attractive safety factor. Cost was a separate area; the entire military was learning valuable but painful lessons about the skyrocketing cost of designing, building, developing and producing new aircraft. In the late 1950s, North American's A3J Vigilante carrierborne nuclear bomber was, according to retired Vice Admiral Don Engen, "costing its weight in 18-karat gold, at the then-current price of $35 an ounce."

Two companies, Chance Vought and McDonnell, had been working on separate private developments for the Navy. Vought, fresh from its triumph with the F-8, had redesigned the Crusader. The company's chief designer, John Russell Clark, and his team came up with a sharply altered shape that drew on much Crusader-derived experience. McDonnell was a young company, but had considerable experience in military aviation: its big XP-67 twin-engined prop fighter of World War II, post-war FH-1 twin-jet Phantom and F2H Banshee – which saw considerable combat in Korea – and single-engined F3H Demon. McDonnell was deeply involved with its AH-1 attack aircraft.

Phantom competition

In July 1955, in an effort to choose one aircraft and save money, the Navy brought the two programmes into direct competition with the issue of an interceptor design requirement. Vought and McDonnell quickly entered the competition and, soon, the field was narrowed to their two examples. The AH-1 had been redesigned and redesignated from a single- to a two-seat, twin-engined fighter: the F4H-1 Phantom II.

Having unofficially designated the F8U-2 (later F-8C) the Crusader II, Vought decided not to call its entry the XF9U, merely naming the aircraft the XF8U-3 Crusader III. Everyone simply called it 'the III'. It was an extremely advanced aircraft, but its possibilities were stillborn when the Phantom eventually won the competition. Vought's development contract was cancelled in December 1958, much to the lament of two generations of fighter pilots. The Phantom went on to become one of the greatest aircraft in military aviation, but the XF8U-3

The prototype XF8U-3 is seen in completed state in the Vought factory at Grand Prairie, Texas, with the second aircraft just behind it. The busy Crusader production line is in the background. Notable are the folded wings, rarely seen later.

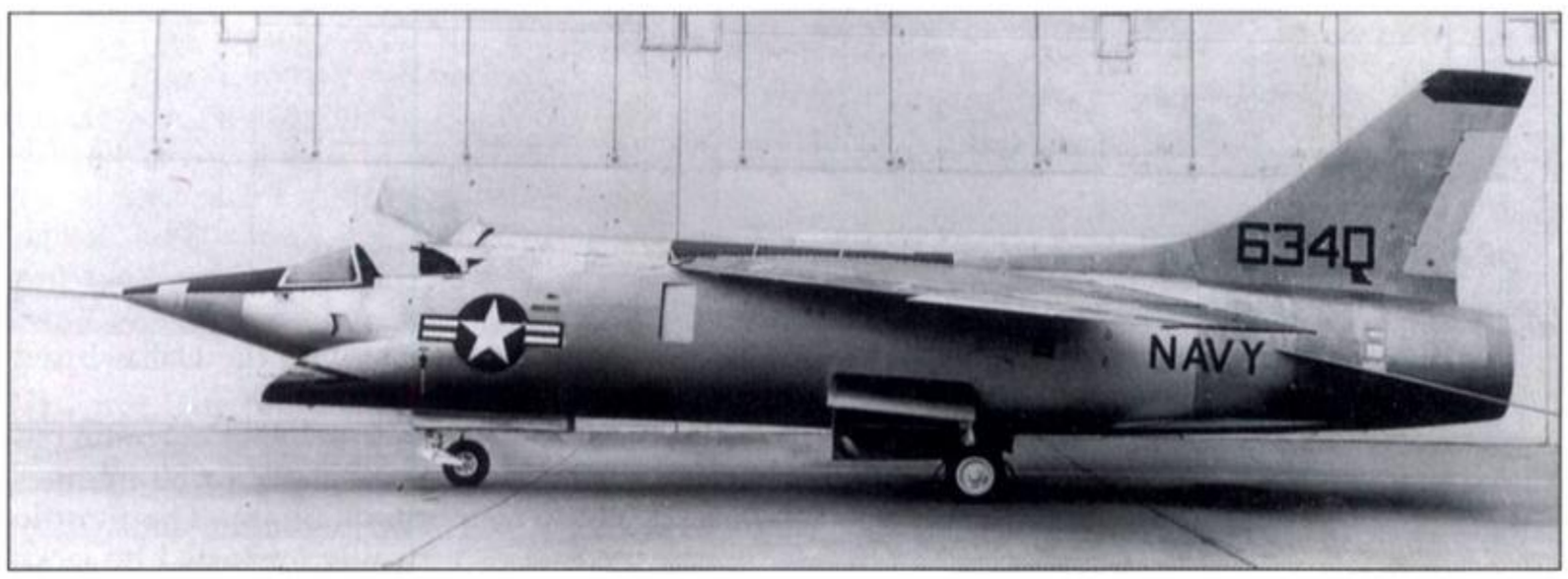
The prototype was delivered by C-124 Globemaster to Edwards AFB for flight test. The fuselage could easily be transported inside the capacious hold, but the one-piece wing had to be strapped externally to the C-124's side.

The XF8U-3 shared many features with its predecessor, the Crusader, but was essentially an all-new aircraft, as demonstrated by the family photograph showing the prototype XF8U-1 with its much larger and faster offspring (far left). Vought termed the F8U-2 the Crusader II, although it differed little from the early F8U-1 Crusader Is. The Crusader III, however, had a much more powerful engine, was larger in all dimensions and had a performance unrivalled by any other aircraft at the time of its debut.

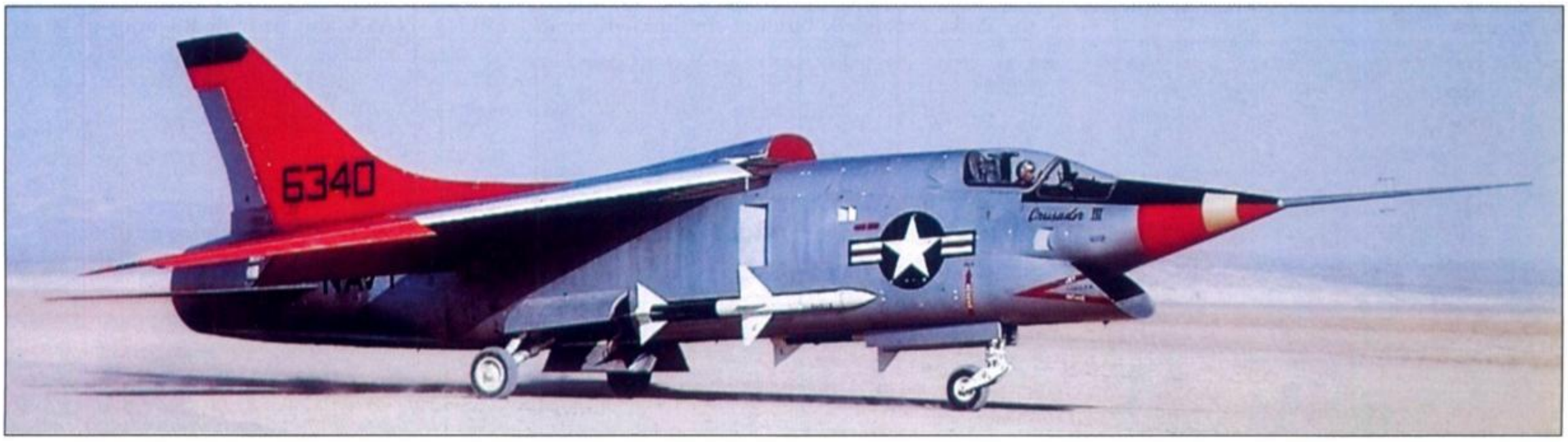
offered tremendous potential and performance that only a few appreciated at the time.

The first III (BuNo. 146340) used a big Pratt & Whitney J75 turbojet with afterburner, producing 29,000 lb (129 kN) of thrust. The second and third aircraft (BuNos 146341 and 146085) used engines that supplied 23,500 lb (104.54 kN) of thrust, but which also offered water injection for longer periods at high speed. Cooling was an ongoing problem, and a solution with water through the compressor helped. Spraying water cooled and made more dense the air coming through the intake as the III approached Mach 0.9. Production aircraft would use yet another modification of the J75 with 28,000 lb (124.56 kN) of afterburning thrust.

Reflecting the tenor of the times, the new Vought product flew without internal guns, but carried two types of air-to-air missiles – the AIM-7 Sparrow and the shorter-ranged AIM-9 Sidewinder, both of which were used extensively in Vietnam and beyond. Weapons avionics and the nose-mounted radar were state-of-the-art, produced by Raytheon – an up-and-coming firm from New England – and Autotechnics, a subsidiary of North American Aviation in California. Autotechnics had produced what can be described as a first-generation head-up display (HUD), tested on an F3D Skyknight. The device used a combined-glass presentation of flight data much like today's F-16. In fact, the technology enjoyed by



Right and below: In its original form the XF8U-3 had a Crusader-style narrow-chord fin. John Konrad made the first official flight on 2 June 1958 at Edwards AFB. A few days earlier he had taken the XF8U-3 briefly aloft on a straight-line hop during high-speed taxi tests.



XF8U-3 pilots

Many pilots flew the XF8U-3, and all were impressed by its performance and handling. In addition to John Konrad, Vought pilots included Jim Malone, Bob Rostine and Jack Walton. The principal Navy pilots were Bob Elder, Don Engen, Bill Lawrence and Larry Flint.

Above: Bob Elder dismounts from an XF8U-3 at Edwards AFB. After leaving the Navy, Elder joined Northrop as chief test pilot, flying the F-5E.

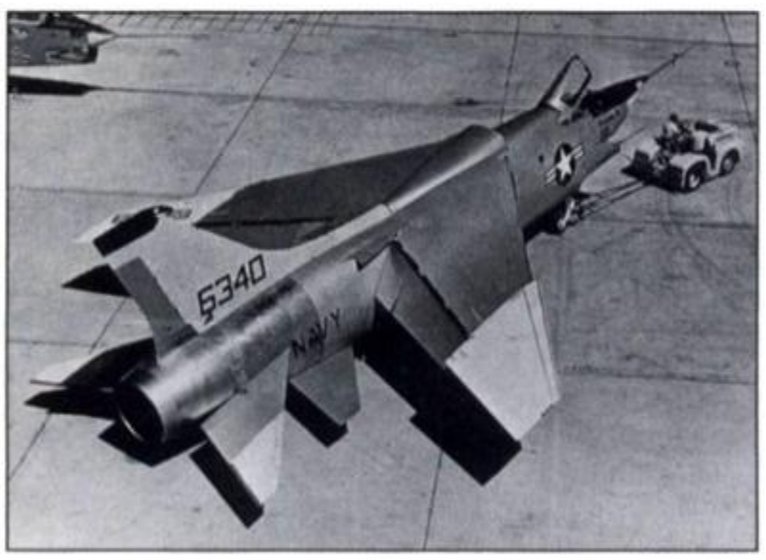
Right: Then-Lieutenant Bill Lawrence poses beside a III at Edwards. Lawrence later rose to three-star rank, commanding an F-4 squadron and being held as a PoW in Vietnam along the way.

Below: Even though over 6 ft tall, Commander Don Engen is almost lost in the cockpit of the III. A Navy Cross holder from World War II, Engen's background was in fighters and dive-bombers.

Below: John Konrad flew the first flight of the XF8U-3, having also undertaken the maiden flight of the XF8U-1 Crusader. He is seen here climbing out of the XF8U-1 after the prototype's 500th flight.

the F/A-18 Hornet of the 1990s derives directly from the Crusader III of the late 1950s.

The third III, BuNo. 146085, was to be the armament demonstrator, but as with so many aspects of the promising programme, the advances of the aircraft's weapons suite were snuffed out upon cancellation.



Above: This overhead view shows the raised ventral fins and wing surfaces to advantage. The small inboard sections were flaps only, while the outboard sections doubled as ailerons at low speeds. At high speeds, roll control was provided by spoilers.

John Konrad took up the III for the first time on 2 June 1958. He had also made the first flight with the XF8U-1 in March 1955, and would make the first flight in September 1965 of the YA-7A Corsair II. Konrad had flown P-47s and B-17s in Europe during World War II with the 27th Fighter Group and 305th Bomb Group, respectively. After the war, he had flown at Edwards AFB during the heyday of the free-wheeling activity made famous by Tom Wolfe in *The Right Stuff*. "The movie glamorised it a little," he remembers, "but not much." Konrad left the Air Force in 1953 and joined Vought. He stayed with the Dallas-based company until he retired in 1990.

On the III's first flight, Konrad encountered a problem that limited the flight to 50 minutes and 350 kt (401 mph; 646 km/h). The throttle link to the fuel control was supported by jack-staffs held in place by the fuel tanks. In flight, the tanks expanded, binding the links. Konrad reduced power and altitude, and the tank returned to its normal size, freeing the link.

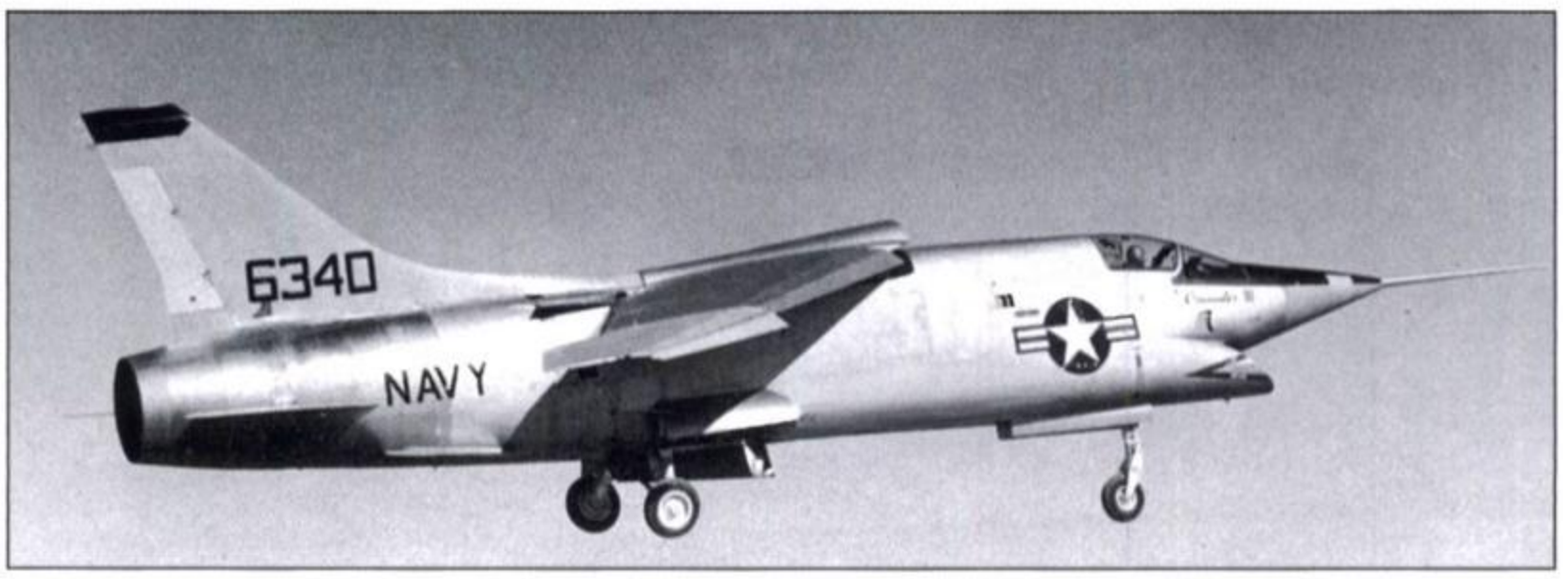
In the spring of 1958, two Navy Preliminary Evaluation (NPE) Teams were established by the Commander, Naval Air Test Center, with one team dedicated to the Phantom, and the other responsible for testing the Crusader III.

Wealth of experience

Captain Robert M. Elder was named Director, Flight Test Division of the NATC organisation, which provided several experienced test pilots. Then-Commander Donald D. Engen headed the Flying Qualities and Performance Branch, while then-Commander Larry E. Flint was the Chief Projects Officer. Elder, Engen and Flint flew both the Phantom and Crusader III. These three senior naval aviators had a wealth of flight experience in peace and war.

Each team also had a project pilot. Lieutenant R. F. Gordon flew the F4H, and Lieutenant William Lawrence was the project pilot for the F8U-3. NASA also provided a pilot-observer for the Phantom, Neil Armstrong, a former naval aviator who 11 years later became the first man to walk on the moon.

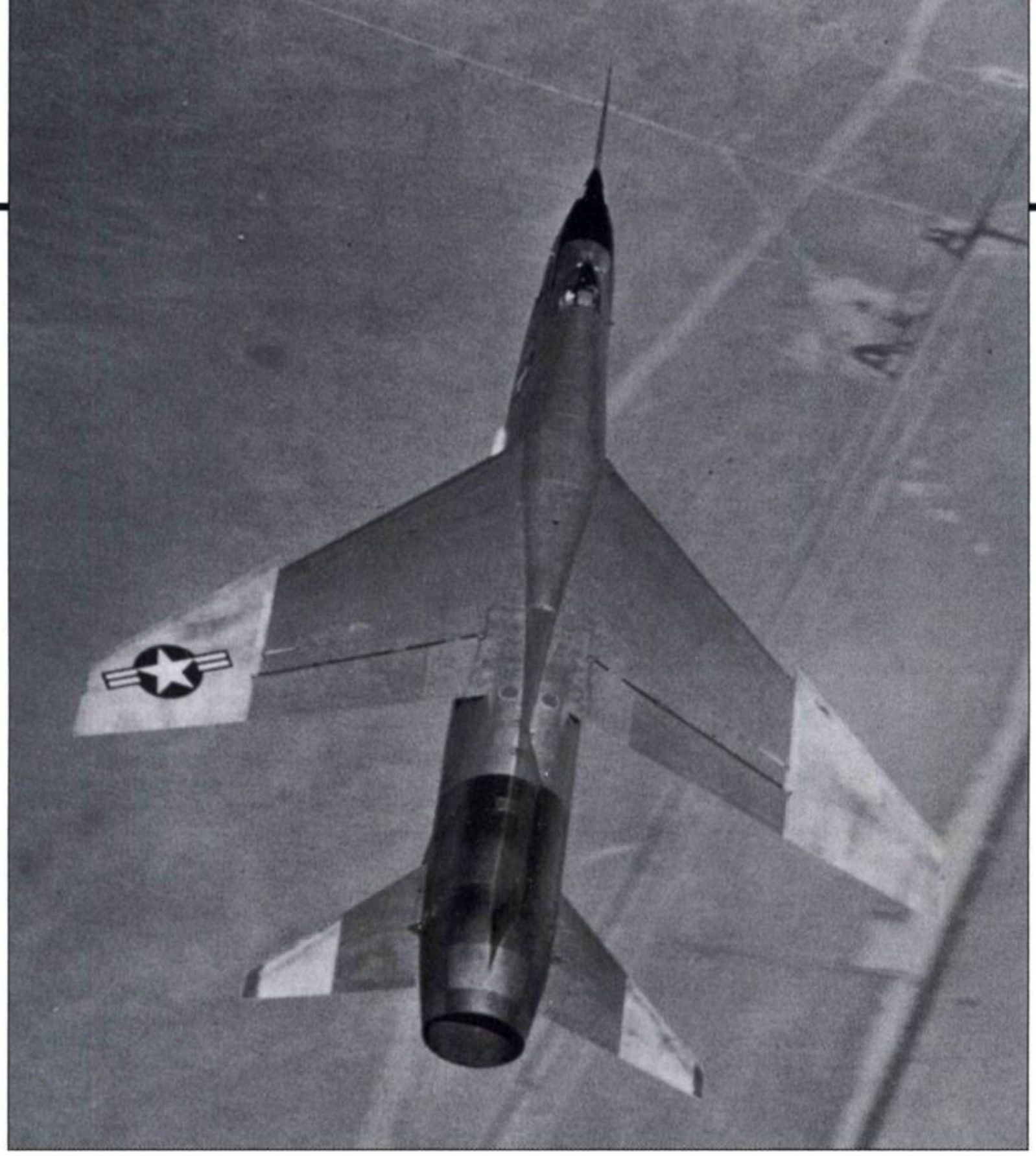
The Vought NPE team flew two aircraft, BuNos 146340 and 146341. Bob Elder declared the III had "very fine flying qualities." He

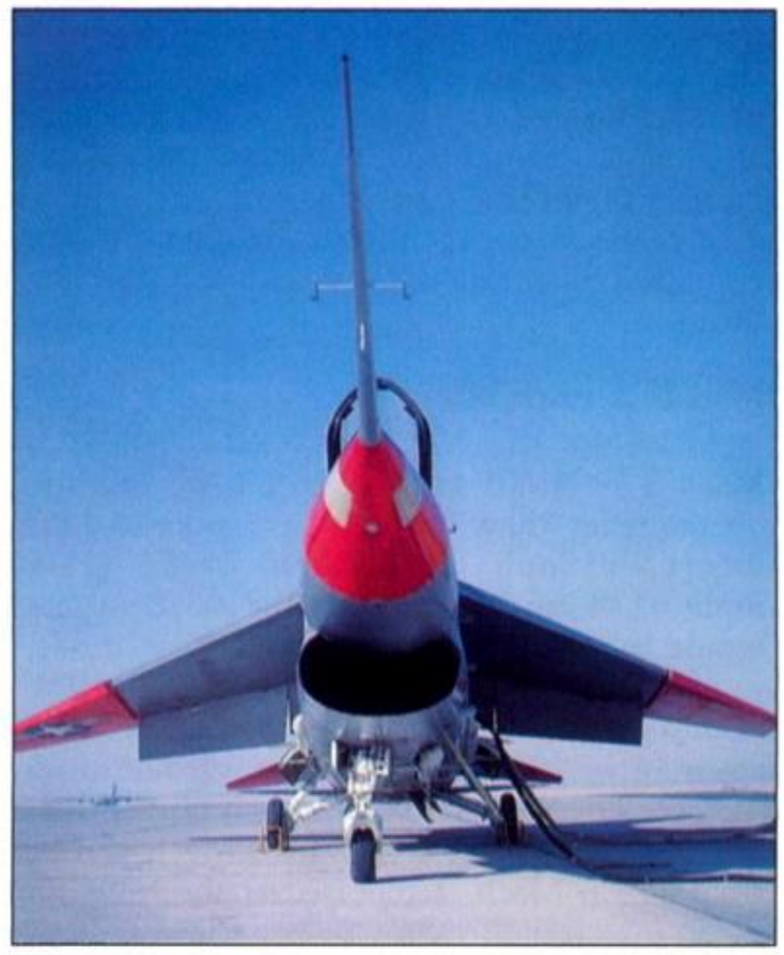


Left: The prototype is seen during an early test flight in landing configuration. The combination of two-section drooping slats, wing-blowing and powerful flaps made the approach handling far easier than with the standard F8U.

Right: The three AAM-N-6 Sparrow III (later AIM-7) missiles were carried in semi-recessed bays. They were to have been augmented by four AAM-N-7 Sidewinders on Crusader-style Y-racks.

XF8U-3 Crusader III

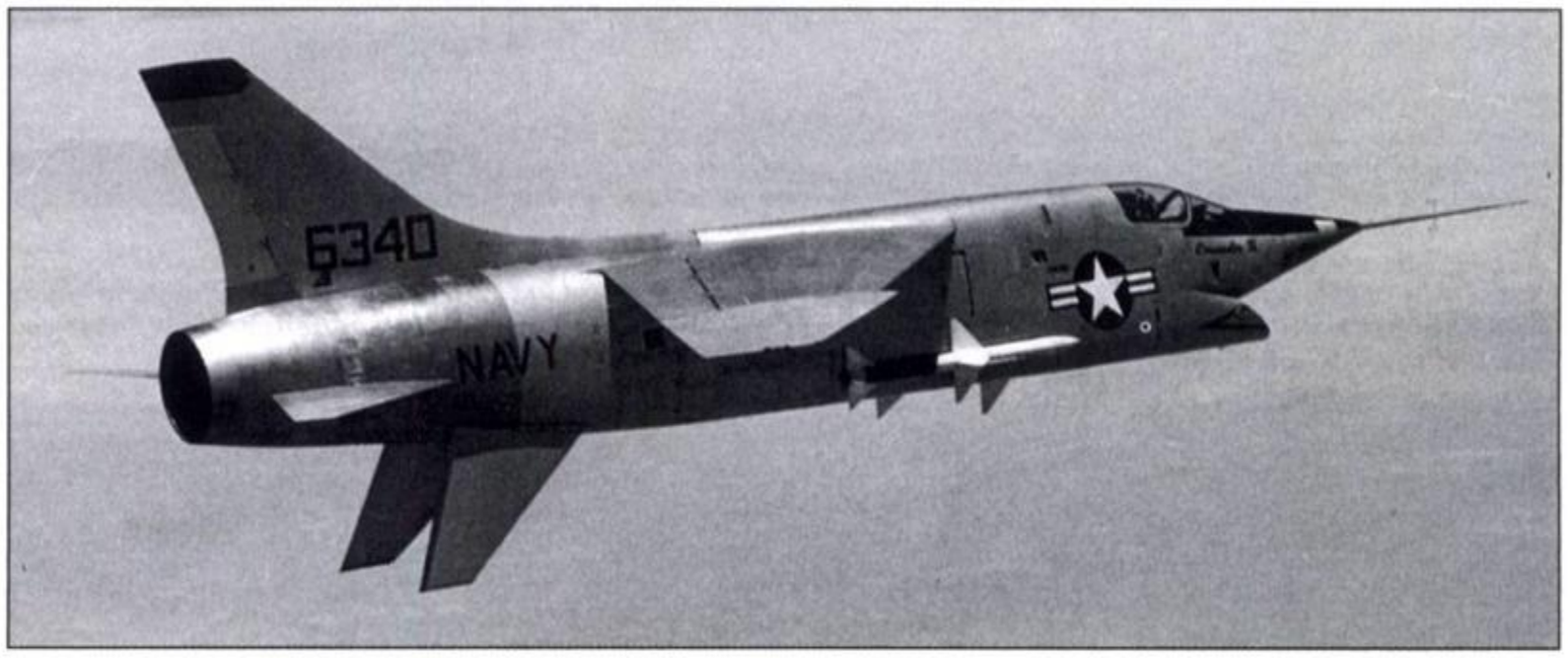




Above: The Crusader III's nosewheel was offset to starboard to enable carriage of the third Sparrow under the fuselage.

Left: This view of the prototype XF8U-3 emphasises the width of the rear fuselage, necessary for area-ruling.

Below: The ventral fins and intake gave the III a shark-like appearance in the air. Its straight-line performance, in terms of speed, climb and acceleration, were unmatched at the time of its flight tests.



knew the F4H was a winner, but Don Engen was more impressed by the Vought aircraft. He flew the big Vought jet several times in September and October, declaring it "the most delightful airplane to fly I have ever seen."

There was more to the Crusader III, including its size. Engen recalled: "The airplane was big, and the only similarities to the earlier Crusader were in the systems within the aircraft. It was a greatly different airplane and that was evident from the time you first saw the large protruding lower lip of the intake and the sheer size of the fuselage. The plane was more slab-sided than the F8U. The cockpit was roomy with a much greater slope to the forward windscreen. The controls, cockpit layout, and instrument panel immediately made the pilot more comfortable."

The XF8U-3s, three of which actually flew, out of five built, ended their days as research vehicles for the National Aeronautics and Space Administration (NASA) at Langley Air Force Base north of Norfolk, Virginia, and at Edwards Air Force Base in California's high-desert country. Because of their performance capabilities, with demonstrated speeds of Mach 2.2 and a zoom-climb altitude of nearly 90,000 ft (27439 m), with sustained levels of 60,000-65,000 ft (18288-19812 m), the Crusader IIIs were ideal space-research aircraft for the embryo period of 1959-61. They studied various aspects of high-speed flight and its effect on fast-jet aircraft.

The Crusader III was never flown to its limits, due, primarily, to the limitations of such a small matter as windscreen construction. The

Perspex could not take the high temperatures of the aircraft's upper performance envelope. Vought wanted to change to a windscreen of glass, which would have withstood the aircraft's impressive speeds, especially with the addition of a planned rocket motor that would have contributed another 8,000 lb (35.59 kN) of thrust.

Mach 3 capable?

Although the XF8U-3 was flown up to Mach 2.39 (1,601 mph; 2576 km/h), everyone on the team knew it could have attained Mach 2.6 (1,750 mph; 2816 km/h) or 2.9 (1,950 mph; 3138 km/h) at 35,000 ft (10670 m), and would have probably passed Mach 3.

Admiral Engen commented on the III's impressive performance. "It was immediately apparent we had an airplane that was not thrust-limited. The airplane had so much power that it was still accelerating as fast at 2.0 Mach as it had been at 1.6 Mach. I reported at the time, and still firmly believe, that the plane could have accelerated out to 3.0 Mach – then an incredible feat – except for the Perspex windscreen which could not withstand the heat generated at speeds above 2.2 Mach. We were told that the canopy would become opaque 20 seconds before the windscreen failed. I spent as much time at high Mach numbers trying to analyse

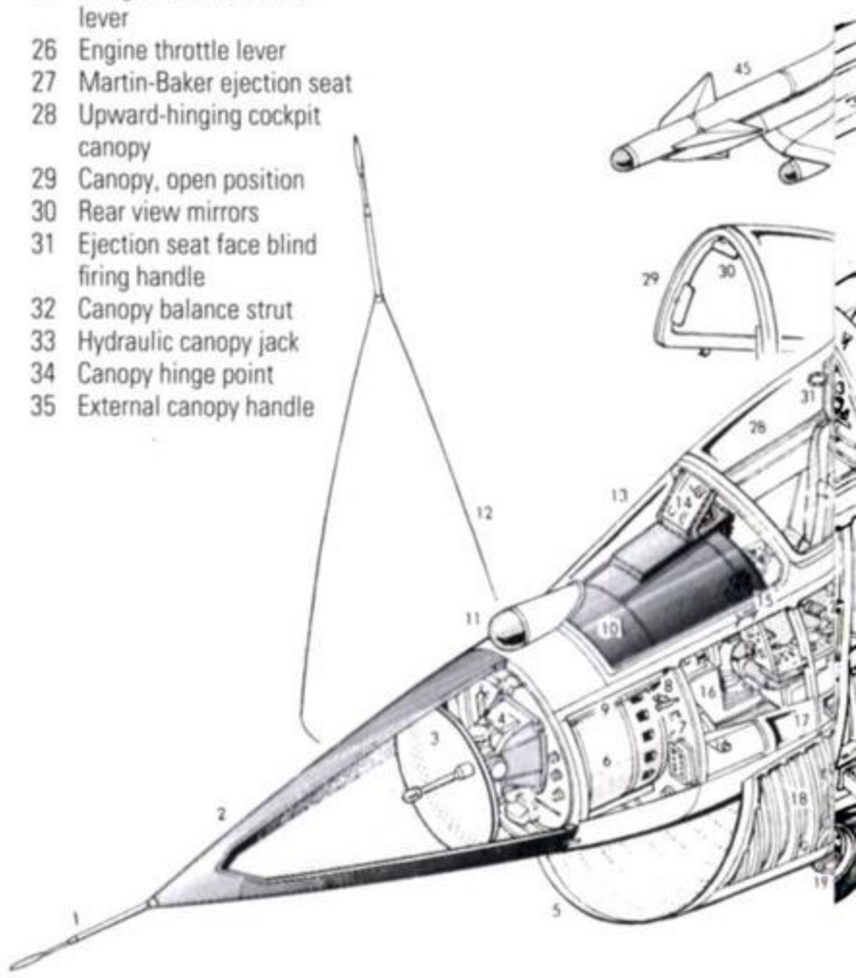
Above and right: To improve directional stability the prototype XF8U-3 was modified with a broader-chord fin. The new fin was incorporated from the outset on the second and subsequent aircraft. The ventral fins rotated to the horizontal position for landing and take-off, although on at least two occasions XF8U-3s landed with them down. This resulted in the destruction of the fins but very little other damage.

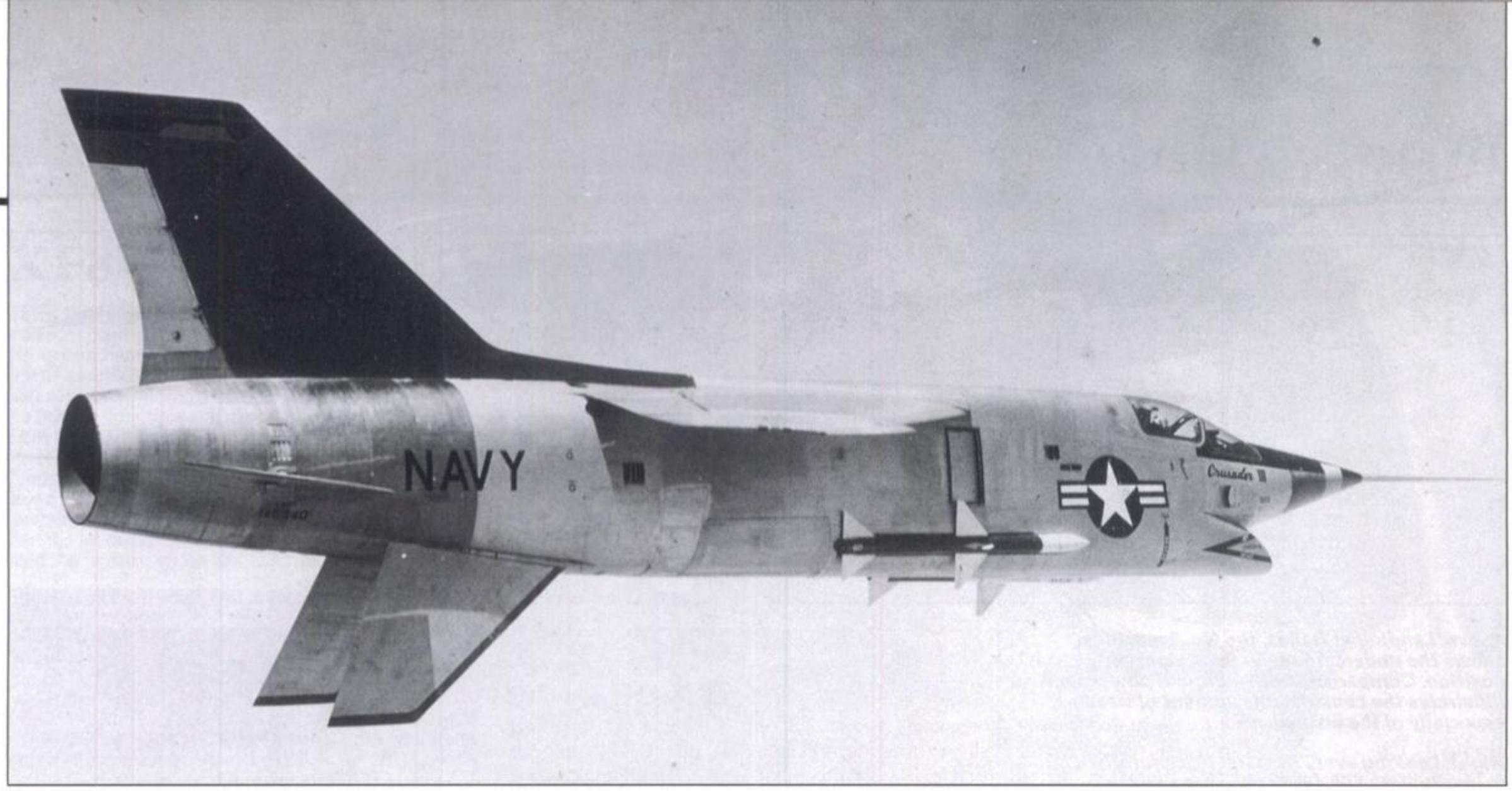
Above: The second XF8U-3 joined the test fleet in September 1958, again flown by John Konrad. It first flew from NAS Dallas before joining the No. 1 aircraft at Edwards.

Below: The No. 2 aircraft lifts off from NAS Dallas on its way to Edwards, the wheels midway through their retraction sequence. Note the empty central Sparrow bay.

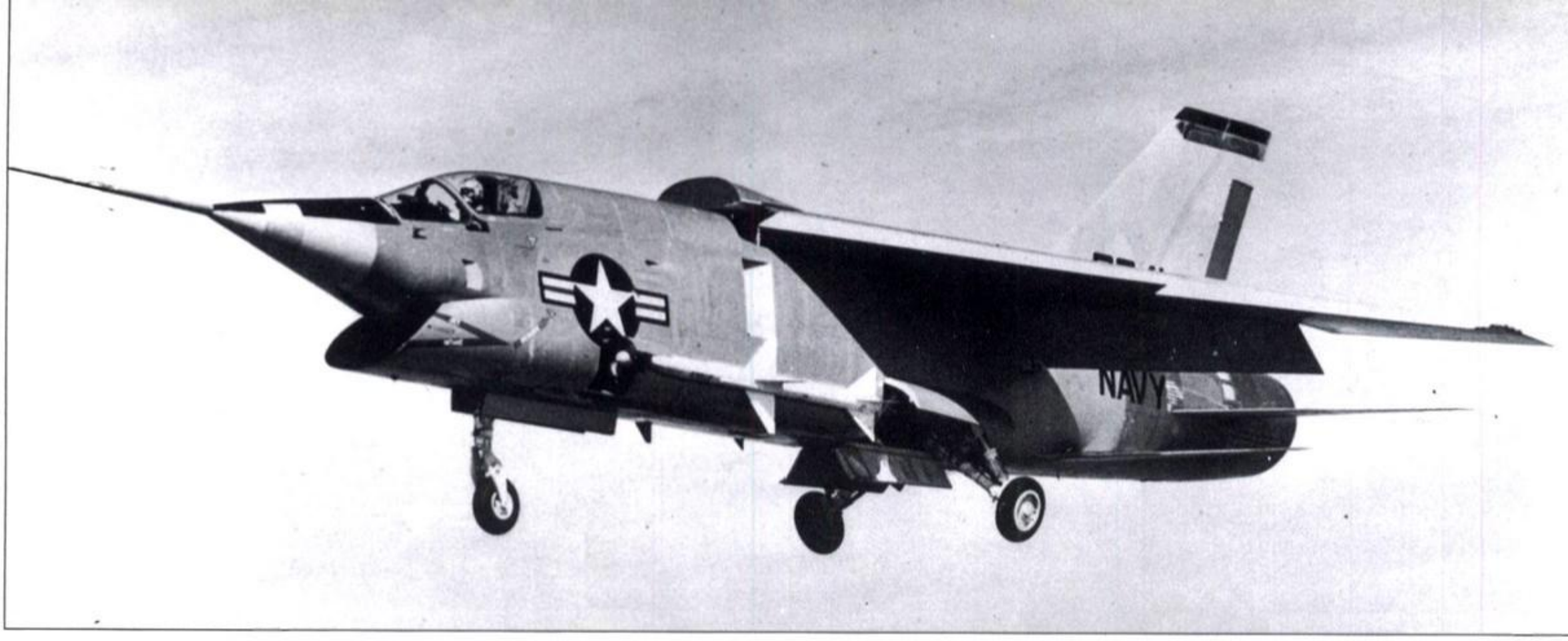
Vought F8U-3 (production) cutaway drawing

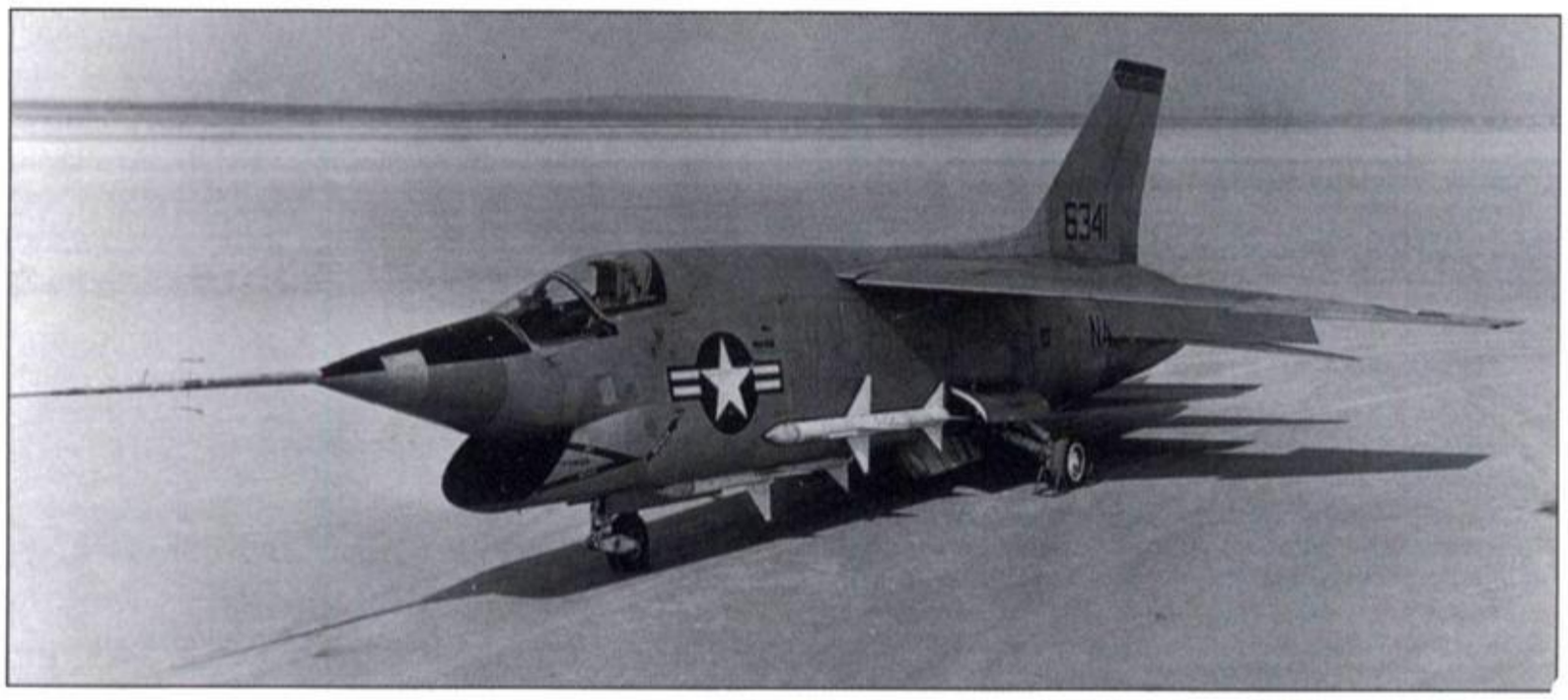
1 Pitot head
2 Glass-fibre radome
3 Radar scanner dish
4 Scanner tracking mechanism
5 Fixed geometry 'Ferri'-type intake
6 Radar equipment module
7 Front pressure bulkhead
8 Temperature probe
9 Radar module withdrawal rails
10 Instrument panel shroud
11 Infra-red search and track seeker head
12 Radome, open position
13 One-piece frameless windscreen panel
14 Radar sight
15 Control column
16 Rudder pedals
17 Radar cooling air spill duct
18 Intake framing
19 Levered suspension nosewheel axle beam
20 Retractable boarding
21 Aft-retracting nosewheel, offset to starboard
22 Ground power socket
23 Boarding steps
24 Cockpit side console panel
25 Wing incidence control lever
26 Engine throttle lever
27 Martin-Baker ejection seat
28 Upward-hinging cockpit canopy
29 Canopy, open position
30 Rear view mirrors
31 Ejection seat face blind firing handle
32 Canopy balance strut
33 Hydraulic canopy jack
34 Canopy hinge point
35 External canopy handle
36 Cockpit rear pressure bulkhead
37 Avionics equipment
38 Canopy emergency release
39 Lower avionics equipment bays
40 Pop-out ram air turbine
41 Telescopic inflight-refuelling probe
42 Refuelling probe housing door
43 Hydraulic jack and hinge link
44 Inertial platform
45 AIM-9 Sidewinder air-to-air missiles
46 Missile launch rails
47 Fuselage missile pylon
48 Dorsal equipment bays access panels
49 Air conditioning pack
50 Electrical equipment bay
51 Turbine-driven generator
52 Fuselage upper longeron
53 Refuelling probe hinge mounting and fuel feed
54 Fuselage lateral semi-recessed missile housing
55 Fuselage pylon attachment point
56 Intake air spill duct





57 Wing incidence hydraulic jack
58 Forward fuselage bag-type fuel tank, total internal capacity 2,036 US gal (1,696 Imp gal; 7710 litres)
59 Fuselage lower longeron
60 Close-pitched fuselage frames
61 Port inboard drooped leading-edge flap panels
62 Inboard leading-edge jack
63 Wingroot rib
64 Centre-section integral fuel tank
65 Wing centre-section multi-spar structure
66 Anti-collision light
67 Starboard wing integral fuel tank
68 Fuel system piping
69 Starboard double-segment drooped leading-edge flaps
70 Inboard flap hydraulic jacks
71 Leading-edge 'dogtooth'
72 Wing-fold hinge joint
73 Outboard leading-edge flap hydraulic jack
74 Starboard navigation lights
75 Outer wing panel, folded position
76 Starboard spoiler panel
77 Wing-fold hydraulic jack
78 Flaperon/spoiler hydraulic actuator
79 Starboard flaperon, down position
80 Flaperon blowing air duct
81 Starboard blown flap
82 Fixed trailing-edge fillet
83 Hydraulic equipment bay
84 Variable-incidence wing hinge mounting
85 Engine compressor intake
86 Intake centre-body fairing
87 Forward engine mounting
88 Pratt & Whitney J75-P-8 afterburning engine
89 Engine accessory equipment gearbox
90 Engine oil tank
91 Hydraulic reservoir
92 Engine turbine section
93 Rear fuselage transfer tanks
94 Rear fuselage break point, engine removal
95 Tailplane control linkages
96 Afterburner duct
97 Tailpipe heat shroud
98 Tailplane spring feel system and autopilot controls
99 Fin mounting post
100 Multi-spar fin torsion box structure
101 Leading-edge ribs
102 Fin-tip antenna fairing
103 VHF/UHF antenna
104 Tail navigation light
105 Tail warning radar
106 Rudder
107 Rudder rib construction
108 Rudder hydraulic actuator
109 Extended exhaust nozzle shroud
110 Variable-area afterburner nozzle
111 Convergent/divergent exhaust nozzle
112 Port all-moving tailplane
113 Tailplane rib construction
114 Tailplane spar box
115 Tailplane pivot mounting
116 Afterburner nozzle control jacks
117 Fin/tailplane mounting mainframe
118 Tailplane hydraulic actuator
119 Deck arrester hook
120 Port folding ventral fin, ground position
121 Arrester hook jack and damper
122 Folding ventral fin hydraulic actuator
123 Port blown flap segment
124 Flap blowing air duct
125 Port flaperon, down position
126 Flaperon/spoiler hydraulic actuator
127 Port spoiler panel
128 Wing fold hydraulic jack
129 Outboard fixed trailing edge
130 Trailing-edge ribs
131 Port navigation lights
132 Three-spar outer wing panel structure
133 Two-segment drooped leading-edge flap
134 Port ventral fin, down position
135 Leading-edge flap hydraulic jack
136 Wing-fold hinge joint
137 Inner wing panel multi-spar structure
138 Port mainwheel
139 Hydraulic retraction jack
140 Shock absorber strut
141 Mainwheel leg strut
142 Landing light
143 Mainwheel bay doors
144 Airbrake hydraulic actuator
145 Ventral airbrake
146 Fuselage ventral missile carriage, offset to port
147 AIM-7 Sparrow air-to-air missile





Above: Landing at Dallas, the No. 2 machine shows the undercarriage in its 'weight-off' position. Comparison with a ground photograph illustrates the considerable amount of travel, especially of the nosewheel.

Right: Looking every inch the 1950s futuristic 'superfighter', XF8U-3 No. 2 is seen on the lakebed at Edwards. The missiles are live, although the No. 2 Crusader III was radarless.

what 'opaque' looked like as I did looking at the instruments."

There were a few other problems with the highly advanced F8U-3. Don Engen recalled: "Early on, it was obvious that one could not always get to those very high speeds because there was an aerodynamic anomaly that developed in the duct depending on rate of acceleration, altitude and attitude. As you accelerated, you could feel the duct go 'critical' at 1.35 Mach. The indication was a duct rumble which started somewhere behind and under the pilot, and as you accelerated, it moved forward. You could feel the rumble in the whole airplane until it reached just under your feet, where the duct would 'unload' with the sound and fury of a 40-mm cannon going off right between your legs. It was an awesome sound and dust would fly all around the cockpit. It was repetitive and when it began, while accelerating, you never knew which to let go of first, the stick or the throttle. I guarantee that each pilot resolved never to do it again."

John Konrad explained that the rumble related to the triple shock waves produced by the air pouring through the III's huge sugar-scoop air intake. The powerful J75 gulped air at three times the amount of the F-8's J57. The III's advanced design called for a futuristic computer to programme the bypass doors, depending on the aircraft's Mach number, altitude, AoA, and yaw. In 1958, however, technology was not up to producing the device, which centred on a series of cams, and pilots had to constantly adjust the setting for the bypass doors as they flew the III. Tweaking the setting was a chore, which occasionally fell by the wayside until the pilot was reminded by the explosive rumble beneath his seat. McDonnell was having the same problem with its entry, programming the intake ramps of their XF4H-1 to work with its two-seater's pair of J79s.

To research the problem, and wearing a full pressure-suit, Konrad took '340' to 62,000 ft (18902 m) then zoomed to 76,000 ft (23170 m), where the engine stalled. With his engine windmilling, he still had hydraulics for flight controls, and after deploying the ram-air turbine – better known as the 'RAT' – to regain his electrics, Konrad made it back to Edwards. Eventually, the group of III test pilots received schedules for programming the bypass doors manually, but the anticipated computer did not arrive before the F8U-3 was cancelled.

Cooling intake

Conrad Lau of the Vought design team took five weeks to fix another problem with engine cooling. He added another intake at the base of '340's vertical tail. Vought also eventually broadened the chord of '340's vertical tail for better directional stability.

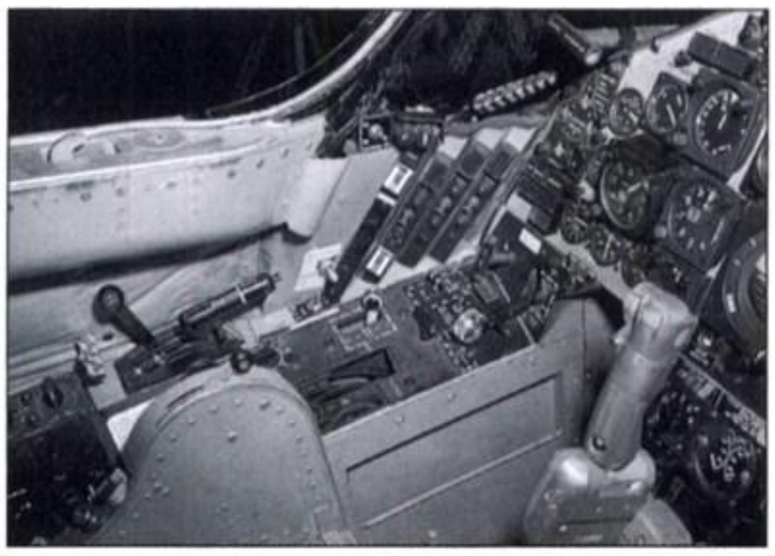
Admiral Engen continued: "After the end of the first phase of the NPE tests, this duct criticality was designed out of the airplane in less than six weeks – I consider that effort one of the greatest aerodynamic design fixes in the shortest time in the history of jet aircraft – and when we returned to test it at the end of November 1958, the F8U-3 was the most delightful airplane to fly I have ever seen. It had the flying qualities of a very nimble fighter. I likened it to the FJ-3 Fury which had control harmony and forces that made it one of the best airplanes in the Navy inventory.

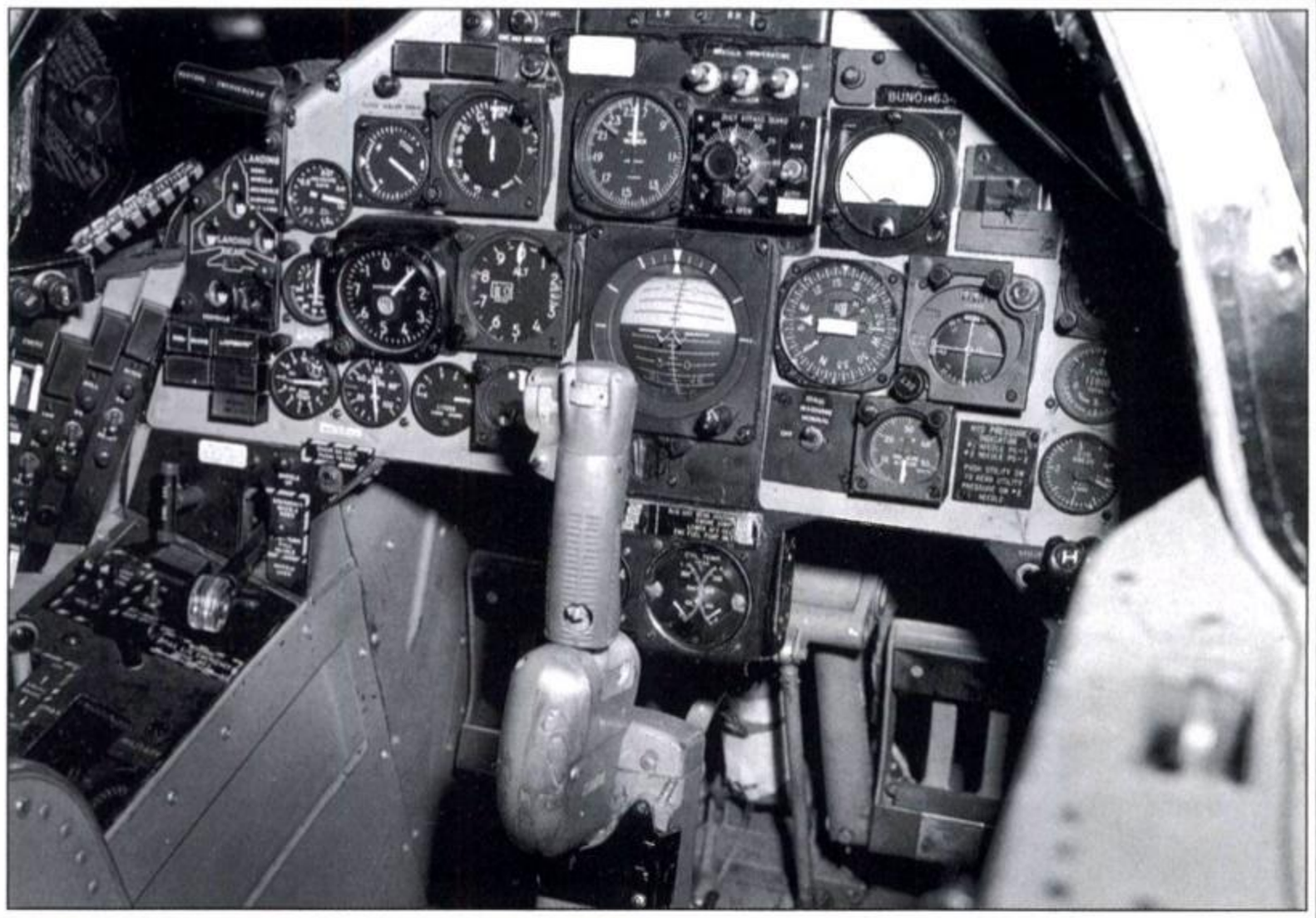
"At that time, we test pilots had not experienced automatic down-linking of flight data. Vought incorporated this capability into the F8U-3, and the installation did away with the laborious data-collection procedures that had

Another F8U/F8U-3 pair shows the second III with an F8U-1E (F-8B). The Crusader III's inlet was fixed but was cleverly designed to cater for speeds of up to Mach 3. Large air spill doors were incorporated into the fuselage sides to dump excess air at low speeds.

XF8U-3 cockpit

Views of 146630's cockpit show a well-designed layout with advanced 'tiering' of various switches that relieved the requirement for complicated side consoles. The unique control stick also shows up well. Instead of the long conventional single-strut affair that pivoted from the cockpit floor, this articulated design gave more room for movement, especially during the landing phase. The stick grip was peculiar to the prototype IIIs. It included four sensors inside the grip to determine how much pressure the pilot applied. Notice also the servo-trim wheels, which were much more accurate than the so-called 'beep trim' of the F8U series, which used the familiar 'coolie-hat' controls.





always been the bane of test pilots and flight-test engineers. There was a trailer near the Vought hangar at Edwards in which this data was received, recorded, and analysed.

"On one flight, I had been doing some less than thrilling performance flying, and I had completed all the points I had been asked to get. It was a beautiful day and as I dropped down over the Antelope Valley to return to Edwards, I had time to enjoy the Dash 3. I levelled off at about 3,000 ft (914 m) above the ground and did a loop, the first ever done in the Crusader III.

"The airplane went around beautifully. I didn't say anything to anyone and landed. But, I had not turned off my data transmission switch and my manoeuvre was seen by everyone. As I taxied into the chocks, shut down, and opened the canopy, John Konrad, chief test pilot for Vought, came up with a twinkle in his eye and slowly shook his finger at me. I had been found out."

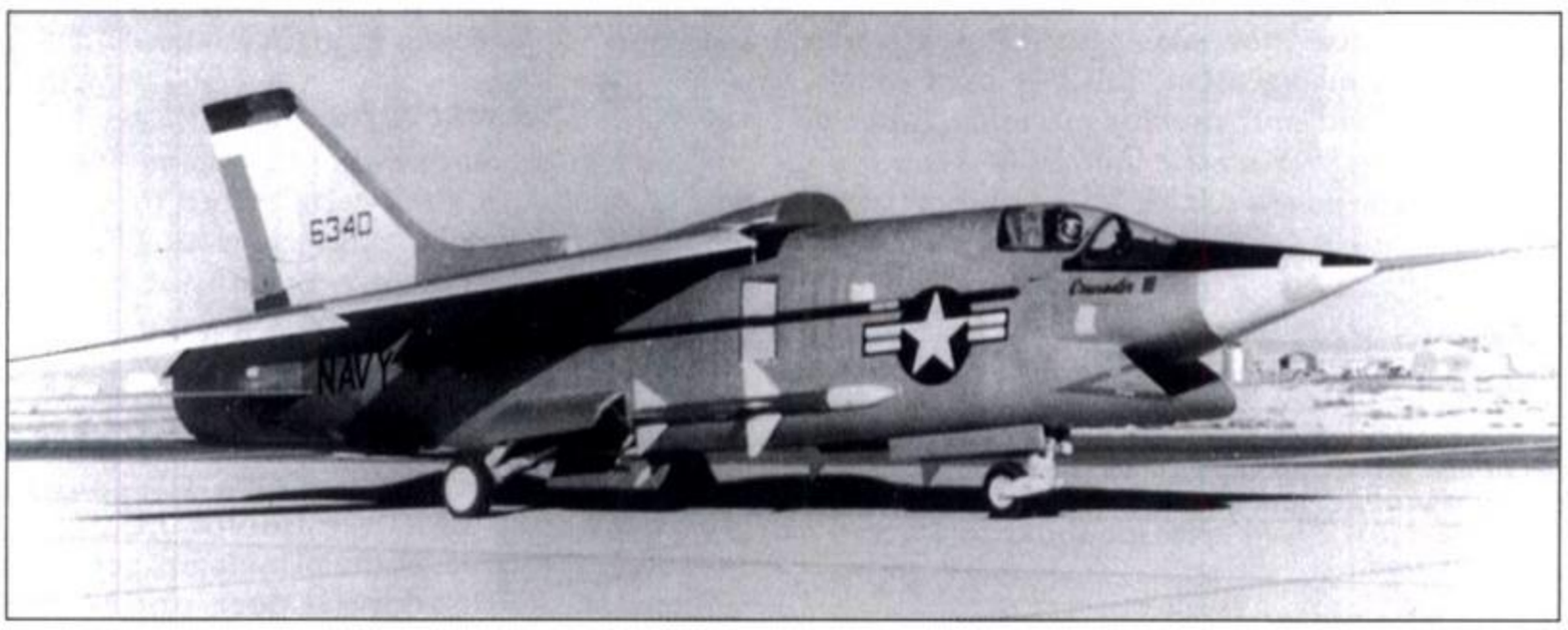
Major achievement

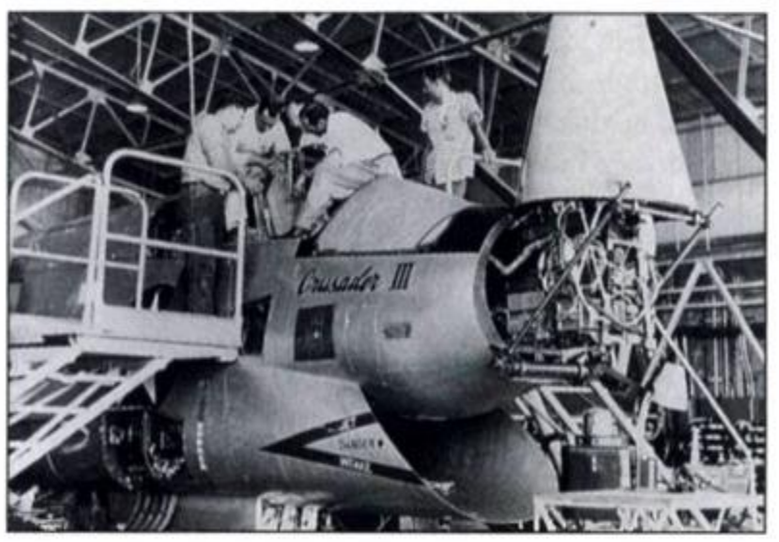
Speaking of his time with the Crusader III, now-retired Vice Admiral Engen remembered, "That was a special time, and the F8U-3 represented a major aeronautical achievement. While the F-8 flew for many years after the III was cancelled, the opportunity for improved performance of the F8U-3's magnitude was never again realised.

"The F8U-3 was amazingly free of major problems and a delight to fly. In retrospect, had we been able to afford two airplanes in the Navy fighter inventory then, we would have had two very fine aircraft."

Bob Elder observed, "The F-4's state-of-the-art avionics and automation of the control systems, as well as its twin-engined, two-crew concept, were overriding factors in its selection over the III. I had my day in court, but the jury was out. A sad loss of a magnificent flying machine. From the hose-nose Corsair on, I liked Vought's style!"

The limiting windscreen was being redesigned when President Dwight Eisenhower cancelled the development contract. He picked

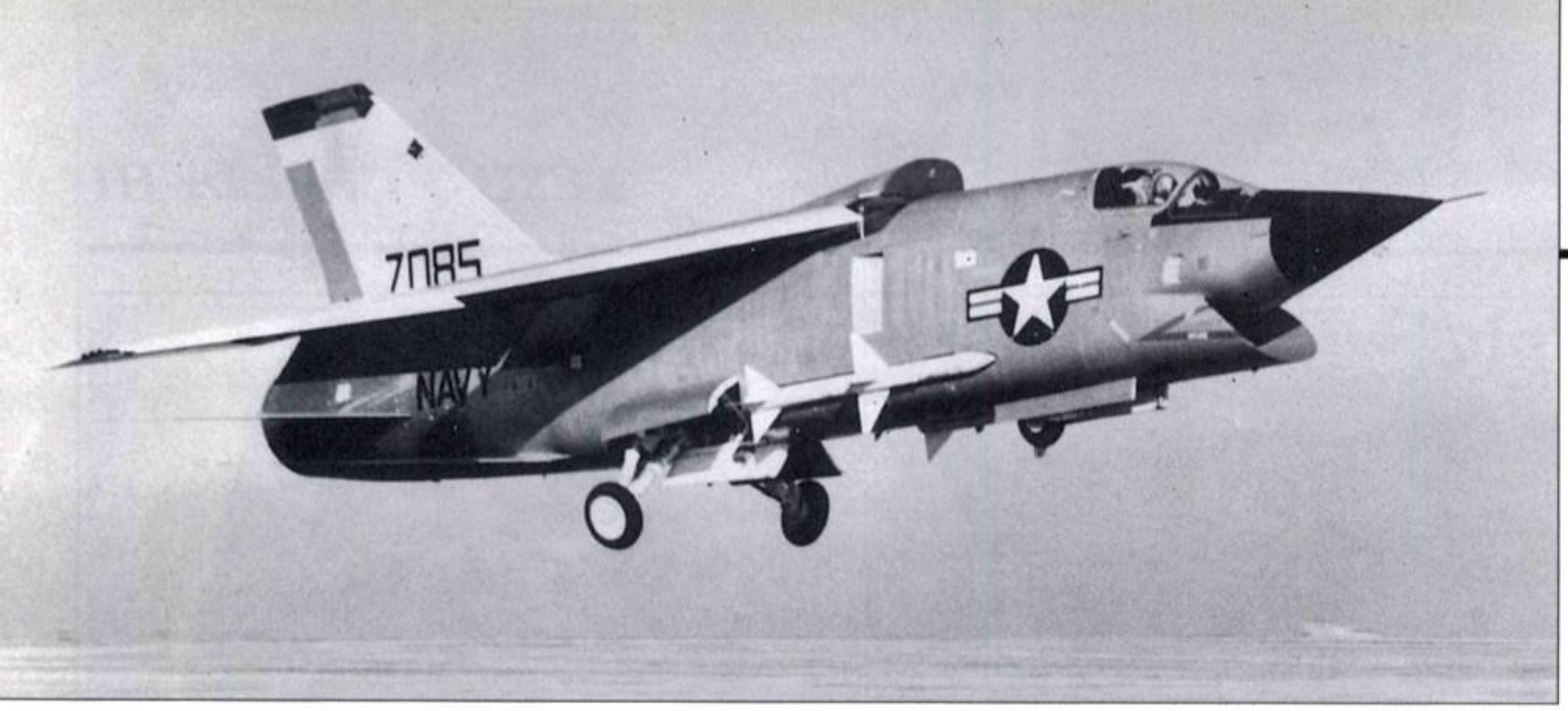




Above: Neither of the first two XF8U-3s had radar, carrying test equipment and ballast instead.

Above: To provide cooling air for the afterburner section of the rear fuselage, an airscoop was fitted in the dorsal fin. This is the first aircraft seen at Edwards. The pilot is wearing a pressure suit for high-altitude trials. The III could achieve around 90,000 ft (27430 m) in a zoom climb and well over 60,000 ft (18290 m) in level flight.

Right: The second aircraft also received the dorsal fin airscoop. Photographed in September 1959 it is seen at Langley, after its transfer to NASA with whom it served on sonic boom tests.



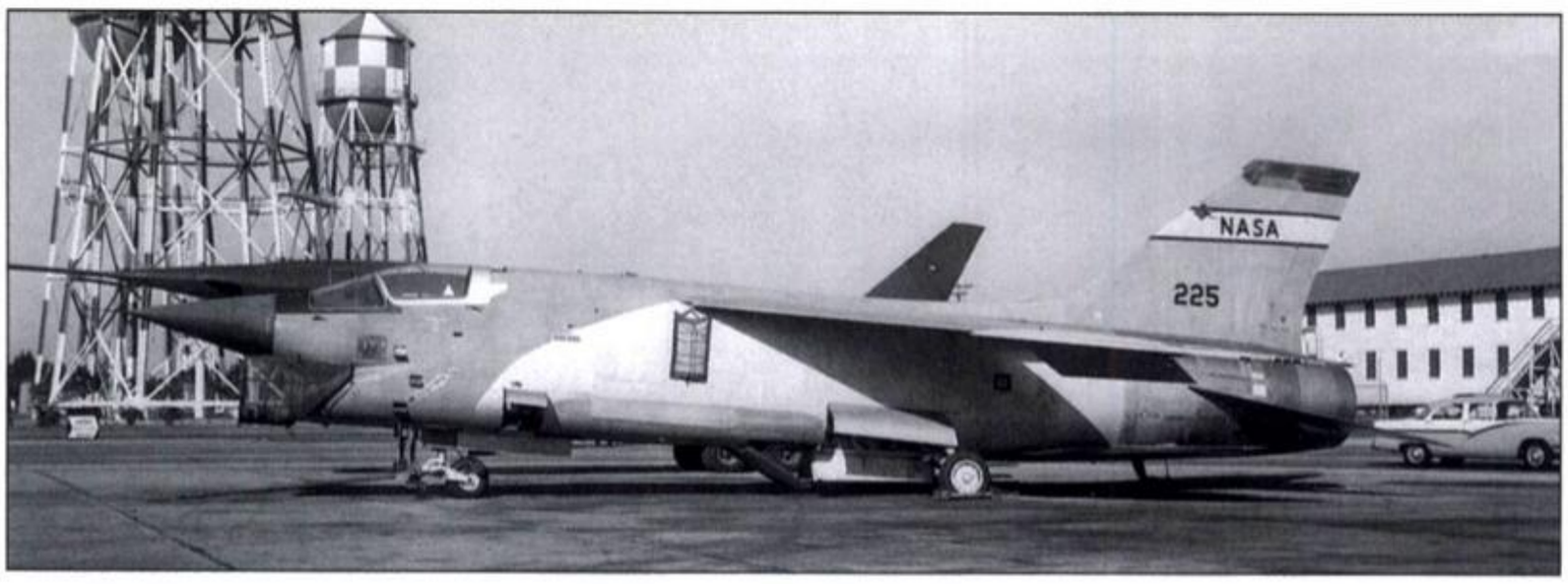
Left and below: These two photographs depict the rarely-seen third aircraft (BuNo. 147085), which was intended for armament and weapon system trials. As such, it dispensed with the long air data instrumentation boom in favour of a short pitot, and carried radar in the black dielectric radome. The nose contours were altered compared to the first two machines, being slightly bulged to accommodate the radar dish antenna.

the F4H based on the relative findings of the NPE teams. There is no doubt that if the Crusader III had gone into production, it would have been the world's fastest jet aircraft for some time.

Young Lieutenant William P. Lawrence earned himself a small niche in naval aviation history when he became the first man to go Mach 2 in a Navy aircraft. A junior member of the NPE, Lawrence was briefing his boss, Commander Flint, on his hop, which would research high-Mach flight. Vought pilots had already flown the III past Mach 2. Captain Elder would fly the F4H. As he briefed Commander Flint, Lieutenant Lawrence realised that his boss was not feeling well. Admitting that he was under the weather, Flint told Lawrence to take the flight.

Supersonic Cadillac

Lawrence climbed to 40,000 ft (12195 m) over the dry lake bed at Edwards. Then, he lit his afterburner and pushed over to accelerate. He compared the big jet's handling through the transonic range to "riding down the interstate in a Cadillac." He passed 1,000 kt (1,148 mph; 1844 km/h) and eventually reached Mach 2.1. When he landed, he found that Bob Elder had only flown his Phantom to Mach 1.5 because of a stipulation by McDonnell that required a familiarisation flight at lower Mach speeds before a pilot could take the St Louis company's pride and joy faster. It took a few months for Lieutenant Lawrence to realise he had been the first naval aviator to go twice the speed of sound in a Navy jet.



All three XF8U-3s served with NASA: Nos 1 (left) and 2 went to Langley while No. 3 (below) went to Edwards, where it received NASA number 225 and a new scheme. Here the aircraft sits at Alameda alongside a Regulus II missile, another Vought product and one which had been cancelled just weeks after the Crusader III cancellation.

It is interesting to speculate on an F8U-3/F-4 partnership in the fleet, for, had the Vought aircraft been produced in numbers, it would have been the fleet's primary interceptor and dogfighter during the Vietnam War. All reports told of the aircraft's acceleration, manoeuvrability and high-speed stability: prime requisites in air-to-air combat.

Speculating on combat engagements between North Vietnamese MiGs and the III, John Konrad believes that the highly-manoeuvrable III "would have eaten them up." The aircraft's excellent control harmony – noted by every former test pilot – imparted an ease of handling that was alien to the stodgy F-4, which Don Engen declared "flew like a truck." At the start of an aerial engagement, the F-4 pilot usually had to unload and use his aircraft's superior power to escape from the lithe MiG-21.

Around a carrier, the III's thinner wing, double leading-edge droops, more aggressive flaps and boundary layer control (BLC) would have been a boon to naval aviators approaching the deck. (BLC was not added to the F-8 until late in the fighter's career, with the F-8J.)

Recalling the III, now-retired Vice Admiral Bill Lawrence repeated his fellow test pilots' reports: the III had "very fine handling qualities – better than the F-4 – especially with BLC, in the low-speed regimes, such as the landing configuration." He felt the III would have done well around the ship, proving a good mount for even junior ensign aviators. Admiral Lawrence also remembered the III's fantastic climb rate, which came from the incredible ram effect of the fighter's huge engine gulping tremendous amounts of air through its giant intake.

Brief NASA career

The first two airframes, 146340 and 146341, flew with NASA for a year before they were sent to NAS Norfolk to be scrapped. The third flying III, 146085, went west to fly at Edwards AFB for a time. BuNos 146086 and 146087 were only partially constructed and eventually suffered the indignities of becoming ground trainers for firefighting teams. None of these powerful, futuristic machines survived. Thirteen pre-production aircraft – BuNos 147088 to 147100 – never got off the planning paper.

That the Crusader III lost out to the Phantom II is no indictment of the aircraft or its manufacturer. The Navy eventually refined and restated its desires more specifically and chose the F-4 because of its two-man, twin-engined layout. By this time, both aircraft had shown their great individual potential, which seemed simultaneously unlimited. Every pilot on the evaluation teams wanted both aircraft, but economics dictated otherwise.

Former F-8 pilot and retired Rear Admiral Paul Gillcrist later wrote, "The brightest moment of US Naval Aviation occurred like a lightning flash, then died somewhat ignominiously." **Peter B. Mersky**

Vought XF8U-3 Crusader III Vought/NATC, Edwards AFB

Developed under the company designation V-401, the Vought XF8U-3 was intended to provide a high-performance, rapid-reaction interceptor for service from US Navy carrier decks. Little was sacrificed in the pursuit of straight-line performance, although the aircraft also featured a very advanced weapon system and was blessed with pleasant handling and good agility. This aircraft is the first prototype in its second major configuration: it sports the definitive broad-chord fin but does not have the dorsal fin airscoop. The aircraft performed the bulk of the flight test work, and after a brief spell with NASA at Langley was scrapped (along with No. 2) at NAS Norfolk, Virginia.

Fuel
Internal fuel capacity was 2,036 US gal (7707 litres), held in five fuselage bag tanks and in the interspar wing tanks inboard of the wing-folds. Production F8U-3s would also have had a retractable refuelling probe housed in a bulged fairing on the port side of the fuselage (like the F8U-1/2).

Weapon system
Neither of the first XF8U-3s had radar fitted, but the third aircraft flew with a Westinghouse APG-74 radar and APA-128 radar set group. This fed information to the Autotechnics missile control system, which had APA-138 cockpit displays. Stores management was handled by a Raytheon Aero-1B system. Production F8U-3s would have featured an APQ-50 radar in a further bulged radome, and would have also incorporated an infra-red search and track sensor in a ball turret just forward of the cockpit (*a là* F8U-2NE).

Wing
The one-piece wing spanned 39 ft 11½ in (12.18 m), and was attached to the fuselage by a rear-spar hinge and two hydraulic jacks at the front. The latter raised the wing to 5° incidence for take-off and landing, instead of the 7° employed on the F8U-1/2. The 2° difference was achieved by the use of boundary-layer control blowing across the trailing-edge flaps and flaperons.

Ejection seat
The three prototypes were fitted with a seat developed by Vought and Stanley Aviation. The Navy would have specified a Martin-Baker seat for production F8U-3s.

Weapons
For its intercept role the F8U-3 was to have carried three AAM-N-6 Sparrow III missiles and four AAM-N-7 Sidewinders. The latter were to have been carried on Crusader-style Y-racks on the sides of the forward fuselage, but are not believed to have ever been tested by the XF8U-3 trials fleet. As befitted the fashion of the time, no thought was given to fitting a gun, and the provision of such a weapon would almost certainly have been as problematical as it later proved with the rival Phantom.

Powerplant
The first XF8U-3 was powered by the Pratt & Whitney J75-P-6, which developed 29,000 lb (129 kN) thrust with afterburning. The second and third aircraft had the J75-P-5 of only 23,540 lb (104.75 kN) thrust, but with pre-compressor water injection cooling which allowed the engine to be run at full power for longer periods. Production aircraft would have featured the J75-P-8 of 28,000 lb (124.6 kN) thrust.

Intake
An unusual feature of the F8U-3 was its 'sugar-scoop' intake. It was capable of providing air at speeds approaching Mach 3, yet had no moving parts. Fuselage-side spill doors downstream were used in the lower speed regime, but on the prototypes they had to be manually scheduled, rather than by a computer (as would have been featured on production aircraft).

By combining superb aerodynamics with one of the best aero-engines ever produced, R. J. Mitchell and his Supermarine team created a pure thoroughbred fighter which became an enduring legend. The Spitfire was the first aircraft that could tackle the hitherto all-conquering Messerschmitt Bf 109, and when the two met head-to-head in the summer of 1940 the result was one of the epic battles of history, and the first major upset to Hitler's plans for a German Empire. For the rest of the war the Spitfire remained the RAF's premier air-to-air fighter, and it lives on as the most poignant symbol of Britain's resolve and resistance, notably during the dark days when the nation and its Commonwealth was all that stood between freedom and Nazism. Here the story of the Merlin-powered land-based fighters is told.

Supermarine SPITFIRE (Merlin-engined variants)

One of Charles Brown's famous wartime air-to-air colour images features a Spitfire Mk VB, the personal mount of the commander of No. 222 Squadron, RAF sometime in late 1941/early 1942. The Rolls-Royce Merlin of another No. 222 Squadron aircraft coughs into life (inset). The development of the Merlin, the most successful inline piston engine of Allied design of the World War II period, was inextricably bound up with that of the Spitfire, one of several important aircraft to use the powerplant.

Reginald Joseph Mitchell, born 20 March 1895, served his engineer apprenticeship with Kerr, Stuart and Co. of Stoke-on-Trent, a builder of steam locomotives. Though he witnessed K5054's first flights, Mitchell died on 11 June 1937 after a long illness, aged just 42.

The Spitfire prototype, K5054, was followed by about 40 different variants (including Griffon-engined aircraft and Seafires). Total production amounted to over 22,000.

The classic elliptical wing shape of the Spitfire, as epitomised by this Mk VB (below right), remained constant throughout the development life of the 'Merlin Spitfires'. Mk XVIs, the last of which appeared in mid-1945, were the final Merlin-engined variants. The classic lines of the early Spitfire marks began to change when a Mk VIII was fitted with a 'rear-view fuselage' in 1943. This was to become a feature of late-build Mk IXs and Mk XVIs and was one of very few major structural changes made to the 'Merlin Spits' during their production life. This Mk XVI (below) was the personal mount of ACM Sir James Robb, seen here on the occasion of his last flight in the aircraft on 21 September 1951, the year in which the last Merlin-engined RAF aircraft were retired.

Supermarine's Spitfire made its maiden flight in March 1936. In May 1949 the last Seafire Mk 47 was delivered to the Royal Navy, ending a production run of 22,000 aircraft all stemming from that same basic design. The intervening 13-year period included the hardest-fought, and technically the most innovatory, war ever fought. In the history of aviation no other design was developed so continuously, so aggressively, so thoroughly or so successfully as that of the Spitfire. The fighter entered service at the end of the biplane era and it remained in front-line service well into the jet age. To keep up with the changing range of threats and requirements, Reginald Mitchell's basic design underwent a protracted programme of incremental improvements. Compared with the prototype, the Seafire 47 had more than twice the engine power, and its maximum take-off weight was more than doubled. Its firepower was increased by a factor of five, its maximum speed was increased by a quarter and its rate of climb was almost doubled. This account covers the development of the Merlin-powered fighter variants of the Spitfire, from the prototype to the Mk XVI. A further part will cover the development and service career of the Griffon-powered fighter variants, and the Seafire. The parallel development of reconnaissance variants of the Spitfire has been covered in detail elsewhere.

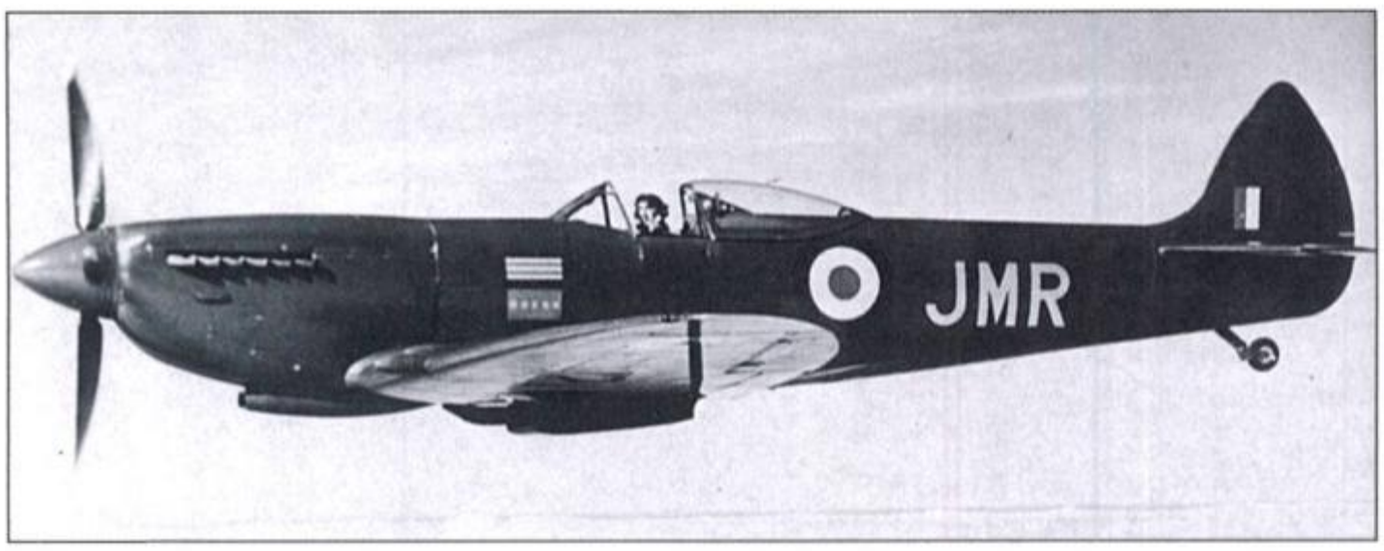
By the early 1930s Reginald Mitchell, the chief designer of the Supermarine Aircraft Company, had established a formidable reputation for creating high-speed floatplanes. His Supermarine S.5 won the Schneider Trophy competition in 1927. His S.6 won it in 1929. In 1931 the Supermarine S.6B won the trophy outright for Great Britain and later raised the World Air Speed record to 407 mph (655 km/h).

This period saw rapid advances in aviation technology. The highly supercharged engine, the variable-pitch propeller, the streamlined all-metal airframe, the cantilever monoplane wing, the enclosed cockpit and the retractable undercarriage all appeared about this time. Each of them promised to give an improvement in aircraft performance.

In 1931 the fastest fighter in the Royal Air Force was the Hawker Fury, which had a maximum speed of 207 mph (333 km/h) – about half as fast as the Supermarine S.6B. In its quest for a fighter with a better performance, in 1931 the Air Ministry issued Specification F.7./30. This called for an interceptor fighter with the highest possible rate of climb and the highest possible speed above 15,000 ft (4573 m).

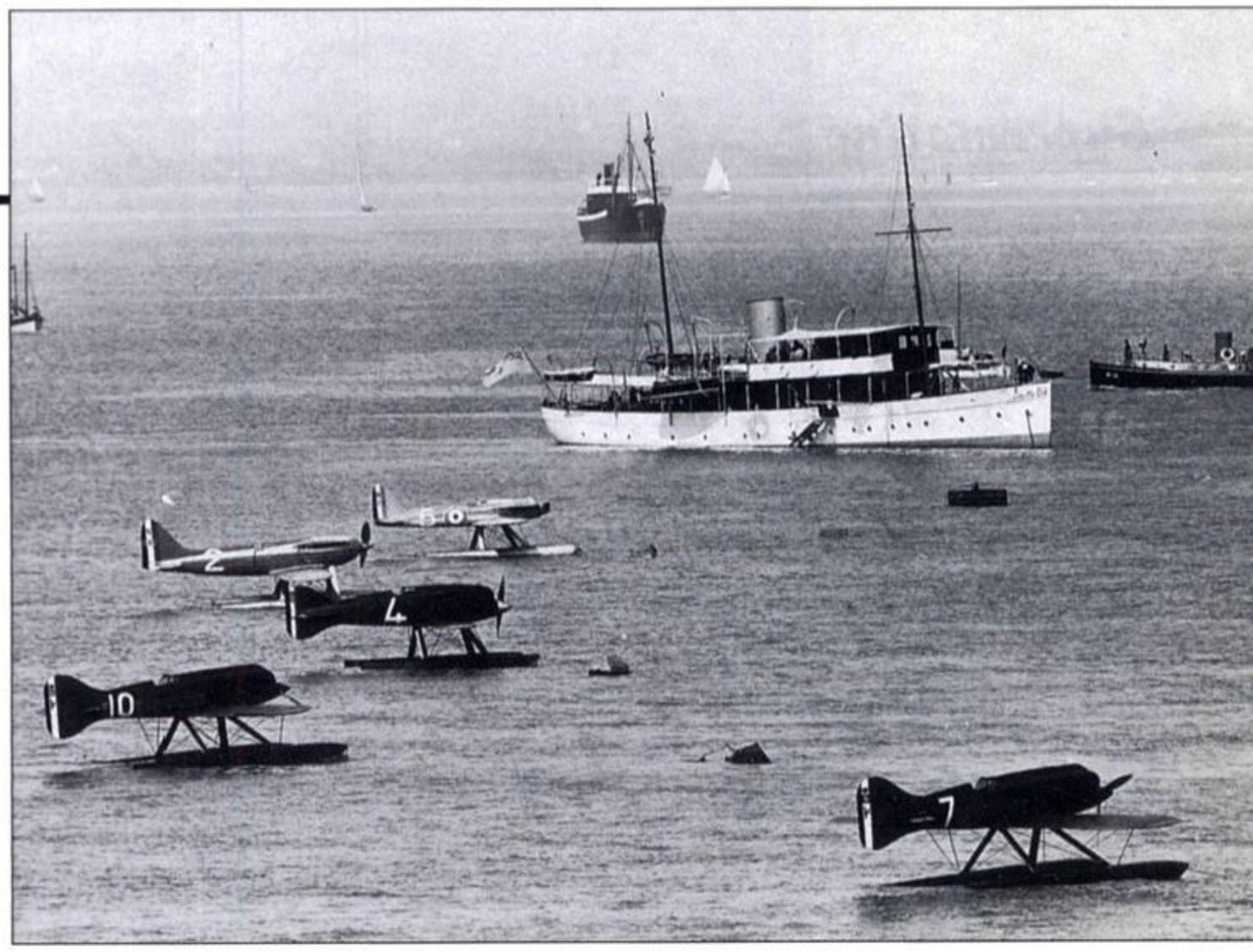
Type 224

Seven companies entered the competition, resulting in five biplane and three monoplane fighters. Reginald

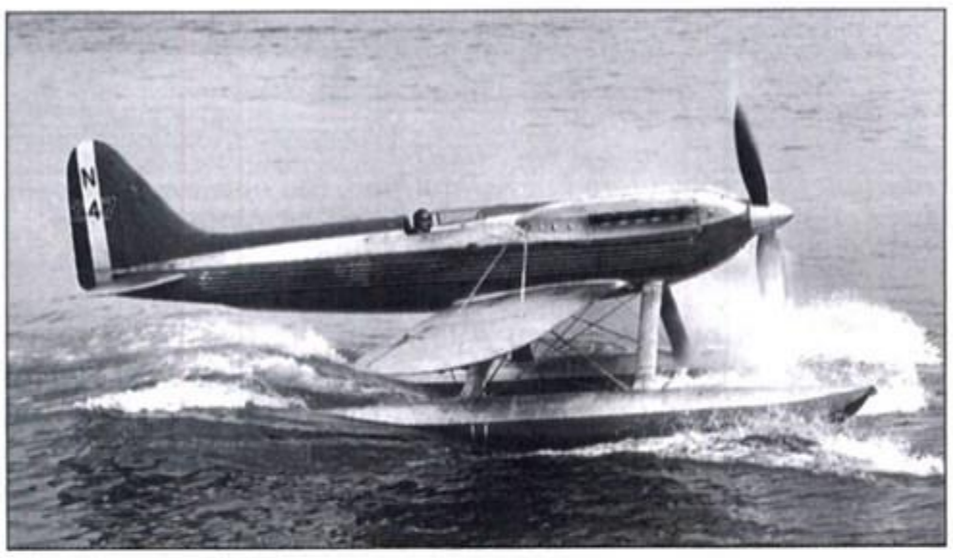


Schneider Trophy

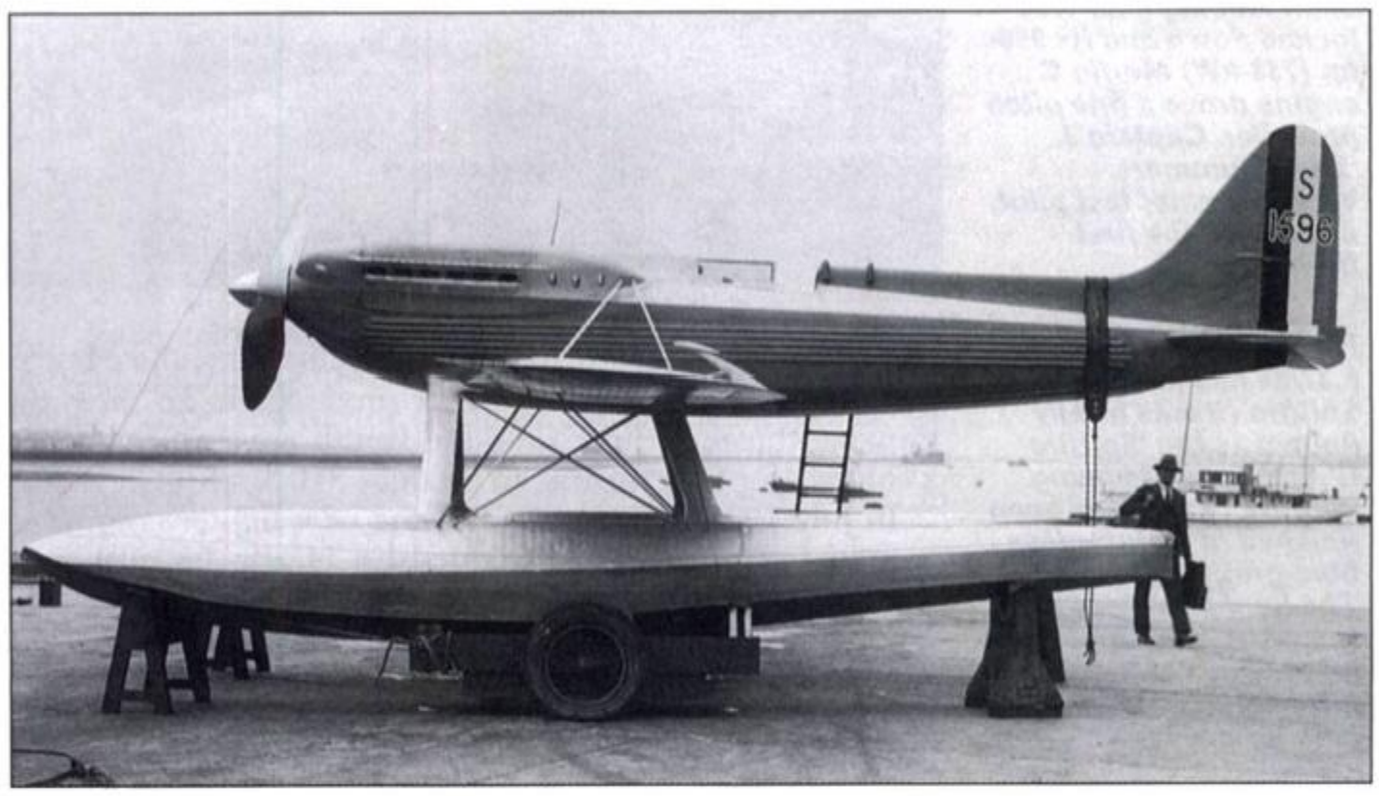
Supermarine's first Schneider Trophy design was a flying-boat. Although the American Curtiss CR-3 biplane floatplanes had scored an emphatic victory in the 1923 contest, Mitchell produced a number of flying-boat proposals, the most promising of which received Air Ministry backing. Powered by a Rolls-Royce Condor and known as the Sea Urchin, the aircraft had a predicted top speed of 200 mph (322 km/h), but problems with the engine transmission system led to its cancellation. Supermarine's next project was as radical as the Sea Urchin was apparently outdated. The S.4 cantilever monoplane of 1925 started a trend in aircraft design that was followed for 20 years. Though the S.4 project was beset with problems, its refined successor, the S.5 (powered, like the S.4, by a Napier Lion engine), took the RAF's High Speed Flight to first and second places in the 1927 Trophy race. For the 1929 contest, Mitchell needed more power to meet the challenge presented by Supermarine's main rivals, the Italian Macchis. Rolls-Royce agreed to supply their new R engine and in doing so laid the foundations for a long relationship between the two companies. A Rolls-powered S.6 went on to beat a Macchi M.67 across the line that year; in 1931 Britain took the Trophy outright and unchallenged with the 2,350-hp (1752-kW) S.6B.



Above: In this scene off the Isle of Wight on 6 September 1929 can be seen the High Speed Flight's winning S.6 (racing number 2) and third-placed S.5 (number 5), along with Italy's two Macchi M.67s and an M.52R moored in the Solent. The S.5 (serialled N219) was the same aircraft that had finished second in the 1927 race.



N247 was the winning S.6 of 1929. Its R engine was rated at 1,900 hp (1417 kW) in the S.6, 1,000 hp (746 kW) more than the Napier Lion in the S.5. By the time the S.6B was ready for the 1931 race, it had 2,350 hp (1752 kW) available.



Supermarine S.6B S1596, sister aircraft of the outright winner of the Schneider Trophy in 1931, was flown by Flight Lieutenant George Stainforth to a 407.5-mph (655.81-km/h) world absolute air speed record on 29 September 1931.

Mitchell's first attempt at fighter design, the Supermarine Type 224, made its maiden flight in February 1934. A monoplane with all-metal construction and a supercharged engine, it was conservative in appearance and retained a fixed undercarriage and open cockpit. Powered by a 680-hp (507-kW) Goshawk engine, its maximum speed was only 228 mph (367 km/h). The Gloster SS.37, a classic fabric-covered biplane with a maximum speed of 242 mph (390 km/h), won the competition and later went into service as the Gladiator.

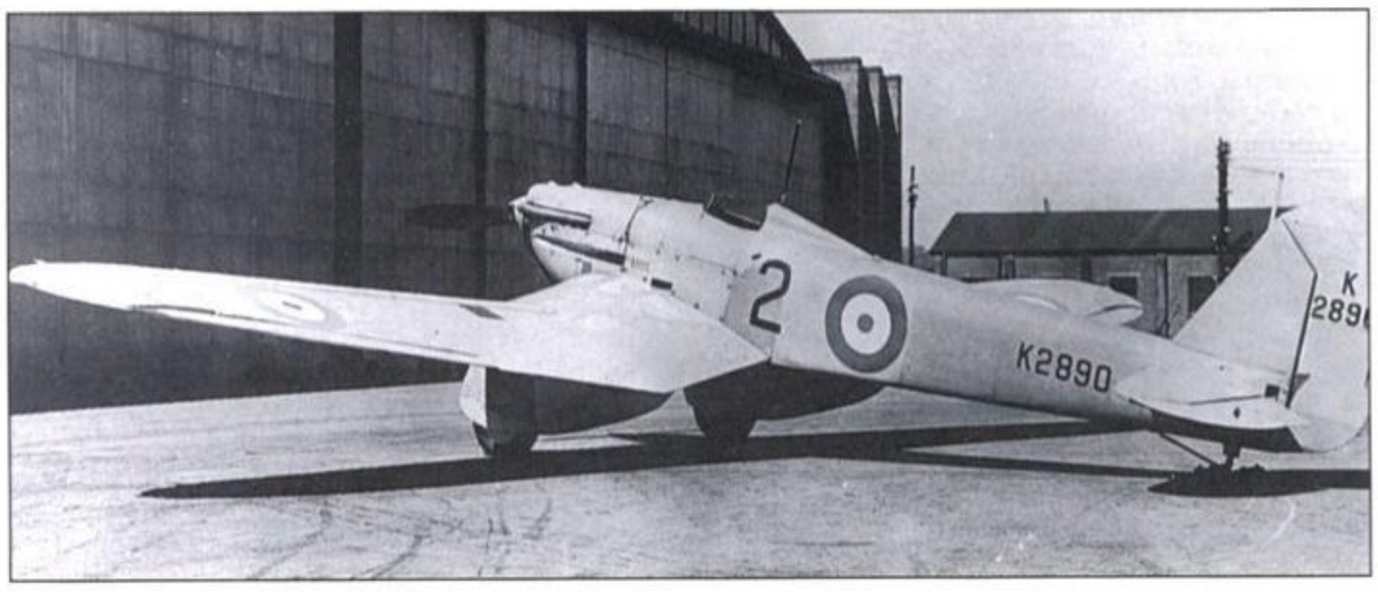
Once the Type 224 was flying, Mitchell saw several ways in which he could improve his design. He persuaded his company to provide initial financing for a more advanced fighter powered by the new Rolls-Royce PV 12 engine (later named the Merlin). The Air Ministry expressed interest in the projected fighter and drew up a new specification, F.37/34, to fund the construction of a prototype.

An oft-repeated myth has it that the Spitfire was 'developed from' the Supermarine racing floatplanes. This is simply not true. Mitchell certainly had learned a great deal about high-speed flight from his racing floatplane designs, but it is quite a different matter to say that the Spitfire was 'developed from' them. The two types of aircraft were intended for completely different roles. There was not a single component of any significance in the Spitfire that resembled its counterpart in the racing seaplane.

'Spitfire' was the name suggested for the Type 224, built to Air Ministry Specification F.7/30. With an inverted gull wing and fixed undercarriage, the Type 224 was hampered by the evaporative cooling system used by its 600-hp (447-kW) Rolls-Royce Goshawk engine. As a private venture, the company redesigned the aircraft around Rolls's new PV.12 engine as the Type 300. Impressed, the Air Ministry wrote Specification F.37/34 around the new design and funded a prototype – K5054, the first true Spitfire.

On 5 March 1936 the Supermarine F.37/34 made its maiden flight from Eastleigh airfield near Southampton, with chief test pilot 'Mutt' Summers at the controls. From the start it was clear that Mitchell's new fighter was altogether more effective than its predecessor. At the suggestion of the Vickers parent company, the new fighter was named the 'Spitfire'. We know that Reginald Mitchell had no part in the choice of that name. When the gifted designer learned of it he commented, "It's the sort of bloody silly name they would give it!"

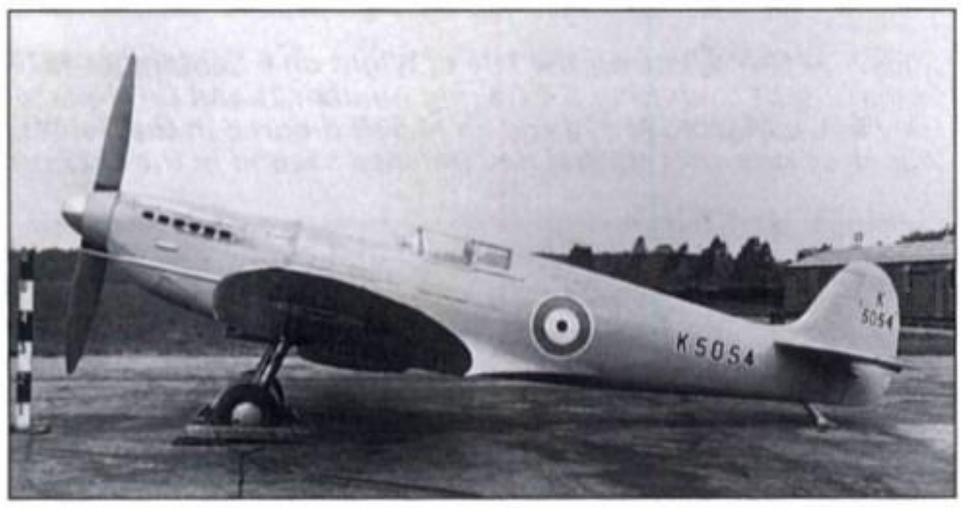
The Spitfire became available just as the Royal Air Force had an urgent need of a high-performance modern fighter. In Germany the newly reformed Luftwaffe was building its



K5054, the prototype

K5054 first flew on 5 May 1936 and over the next three years accumulated about 260 hours flying time. By October 1938 gun heating trials were complete and K5054's part in the development of the Spitfire had effectively come to an end. The aircraft was flown to Farnborough and employed as a 'high-speed hack' aircraft and in the planning of the world air speed record attempt in the 'Speed Spitfire'. Its flying career finally came to an end on 4 September 1939, the day after war was declared on Germany, when Flt Lt 'Spinner' White was killed when the aircraft nosed over onto its back in a landing mishap. The aircraft was not repaired.

Above: During the three days after the prototype's first flight, undercarriage fairings were fitted. Complicated and prone to malfunction, they were later simplified, the new arrangement becoming standard on production Spitfires. Note also the course pitch propeller.



Above: The F.37/34 prototype at Eastleigh is seen a few hours before its maiden flight. At this stage the aircraft was unpainted, its unfaired main landing gear was locked down and its 990-hp (738-kW) Merlin C engine drove a fine pitch propeller. Captain J. 'Mutt' Summers, Vickers's chief test pilot, undertook the first flight.

Right: By May 1936, F.37/34 had been named Spitfire (it was briefly known as the 'Spitfire II', the Type 224 being 'Spitfire I') and had been finished in a high-gloss blue-grey paint scheme. The long pitot tube on the wing was fitted for initial trials and was later replaced with a smaller example.

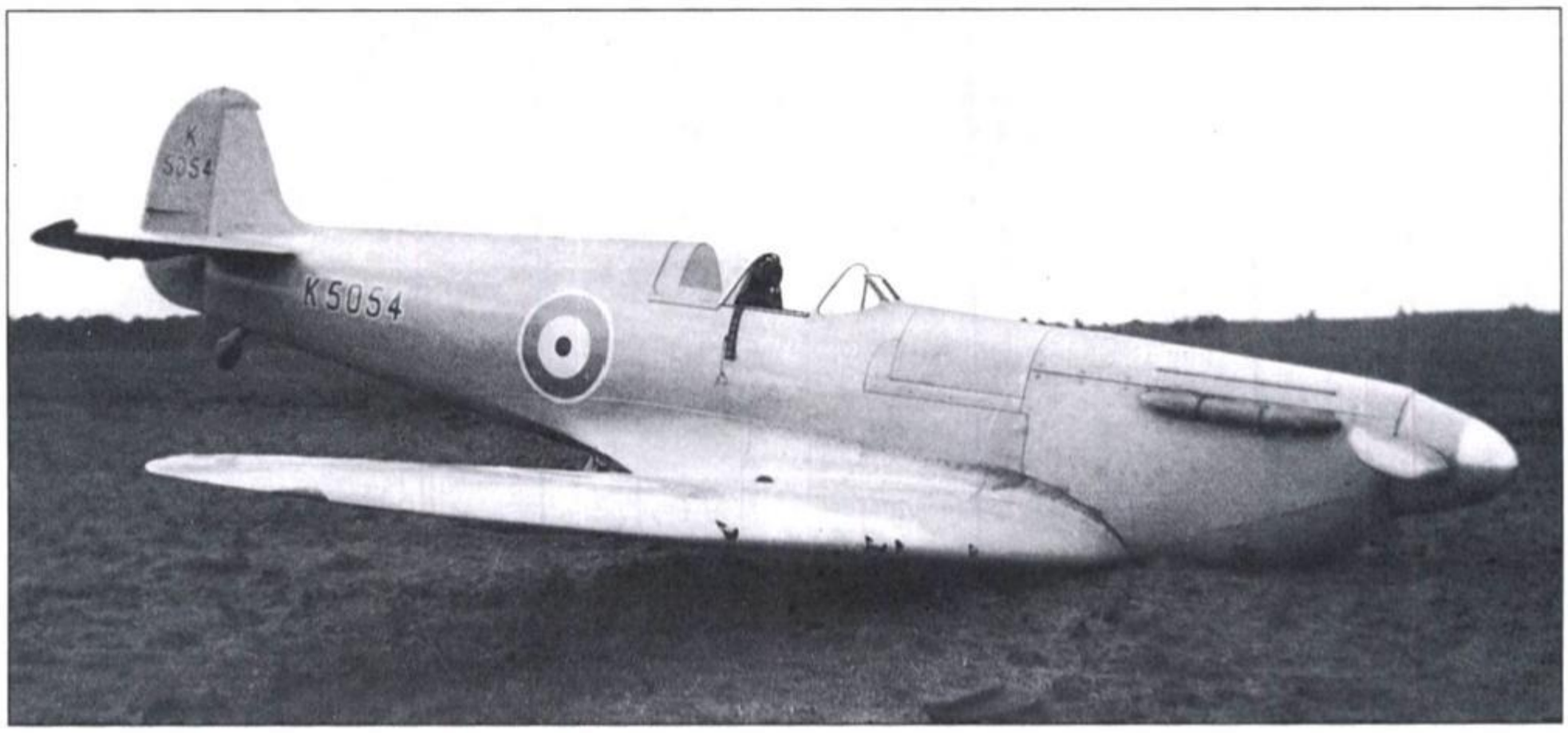
strength rapidly. Its new monoplane fighter type, the Messerschmitt Bf 109, was in large-scale production. To meet the growing threat, in June 1936 the British government signed a contract for Supermarine to produce 310 Spitfires.

In July 1936 the prototype of the new fighter completed its initial service trials at Martlesham Heath. Its maximum speed was 349 mph (562 km/h) at 16,800 ft (5122 m), and it could reach 30,000 ft (9145 m) in 17 minutes.

Most aspects of the Spitfire's flight trials went smoothly. In December 1936 the prototype resumed flying after the installation of its armament of eight Browning 0.303-in (7.7-mm) machine-guns. The initial firing trials with these weapons took place over the North Sea in March 1937, with the aircraft flying at 4,000 ft (1220 m). All eight guns fired their full complement of ammunition with no stoppages. A few days later the prototype went to 32,000 ft (9755 m) to fire the guns at high altitude. In the climb most of the weapons had frozen solid, and the test was a complete failure. One gun fired 171 rounds, another fired eight rounds, one fired four rounds and the remaining five guns refused to fire at all. That was bad enough, but when the Spitfire touched down at Martlesham Heath the shock of the landing released the breech blocks of three weapons. Each loosed off a round in the general direction of Felixstowe, fortunately without hitting anyone.

Frozen guns

In the months to follow, Supermarine engineers tried various schemes to prevent the guns freezing, using progressively greater amounts of hot air ducted the radiator under the starboard wing. It proved a long process, however. When the first production Spitfires were delivered to the Royal Air Force in the summer of 1938, their guns still would not fire reliably at high altitude. At a meeting of the Air Council, Marshal of the Royal Air Force Sir Cyril Newall, the Chief of Air Staff, commented: "If the guns will not fire at heights at which the Spitfires are likely to encounter enemy bombers, the Spitfires will be useless as a fighting aircraft."



K5054's first major accident took place on 22 March 1937 when Flying Officer Sam McKenna made a forced landing after experiencing engine trouble. Between August and December 1936, the aircraft was grounded for modifications, including the installation of a 1,045-hp (779-kW) Merlin F engine and eight 0.303-in Browning machine-guns. It took 10 months to devise a heating system to prevent the guns from freezing at altitude.

The occasion of K5054's first public appearance was a display of Vickers types before 300 invited guests at Eastleigh on 18 June 1936. Other aircraft on show were K4049, the B.9/32 bomber prototype (later ordered by the RAF as the Wellington); K7556, the pre-production Wellesley single-engined bomber; and K5780, the ninth production-standard Walrus amphibian. In 1938, the Supermarine Aviation Works (Vickers) Limited and its parent company Vickers (Aviation) Limited of Weybridge were taken over by Vickers-Armstrong Limited.

It took until October 1938, more than a year and a half after the problem was first revealed, to devise an effective system to prevent the guns freezing. That month, a service pilot climbed the prototype to 32,000 ft (9756 m) and fired the contents of all eight ammunition boxes, without a single stoppage. From then the gun-heating modification was incorporated in all Spitfires on the production line.

Spitfire enters service

In August 1938, 29 months after the maiden flight of the Spitfire, No. 19 Squadron at Duxford was the first service unit to receive the new fighter. By December it had its full complement of aircraft, and was followed by other squadrons that began to convert to the type.

On 3 September 1939, when Great Britain entered the war against Germany, the RAF had taken delivery of 306 Spitfires. Of these, 187 were serving with 11 Fighter Command squadrons (Nos 19, 41, 54, 65, 66, 72, 74, 602, 603, 609 and 611). A further 71 Spitfires were held at maintenance units, ready for issue to replace losses. Eleven Spitfires served as trials machines, either with the makers or at service test establishments. One Spitfire was temporarily allocated to the Central Flying School, for use by those writing the Pilot's Notes on the aircraft. The remaining 36 Spitfires had been lost in accidents.

The Spitfire went into action against enemy aircraft for the first time on 16 October 1939. On that day nine Junkers Ju 88s of Kampfgeschwader 30 attacked Royal Navy warships in the Firth of Forth. Nos 602 and 603 Squadrons, based at Drem and Turnhouse, respectively, scrambled to engage the raiders. Flight Lieutenant Pat Gifford of No. 603 Squadron shot down one bomber and Flight Lieutenants George Pinkerton and Archie McKellar of No. 602 Squadron destroyed another. Fighters of No. 603 Squadron engaged another Ju 88 and shot out one of its engines, but it escaped out to sea.

In the months that followed, Spitfires had sporadic encounters with individual German bombers, minelayers or reconnaissance aircraft. For the most part, however, this was a period of expansion of the force and of training for the battles to come. By the beginning of May 1940 another eight squadrons (Nos 64, 92, 152, 222, 234, 266, 610 and 616) had received Spitfires, to bring the strength of the force to 19 squadrons.

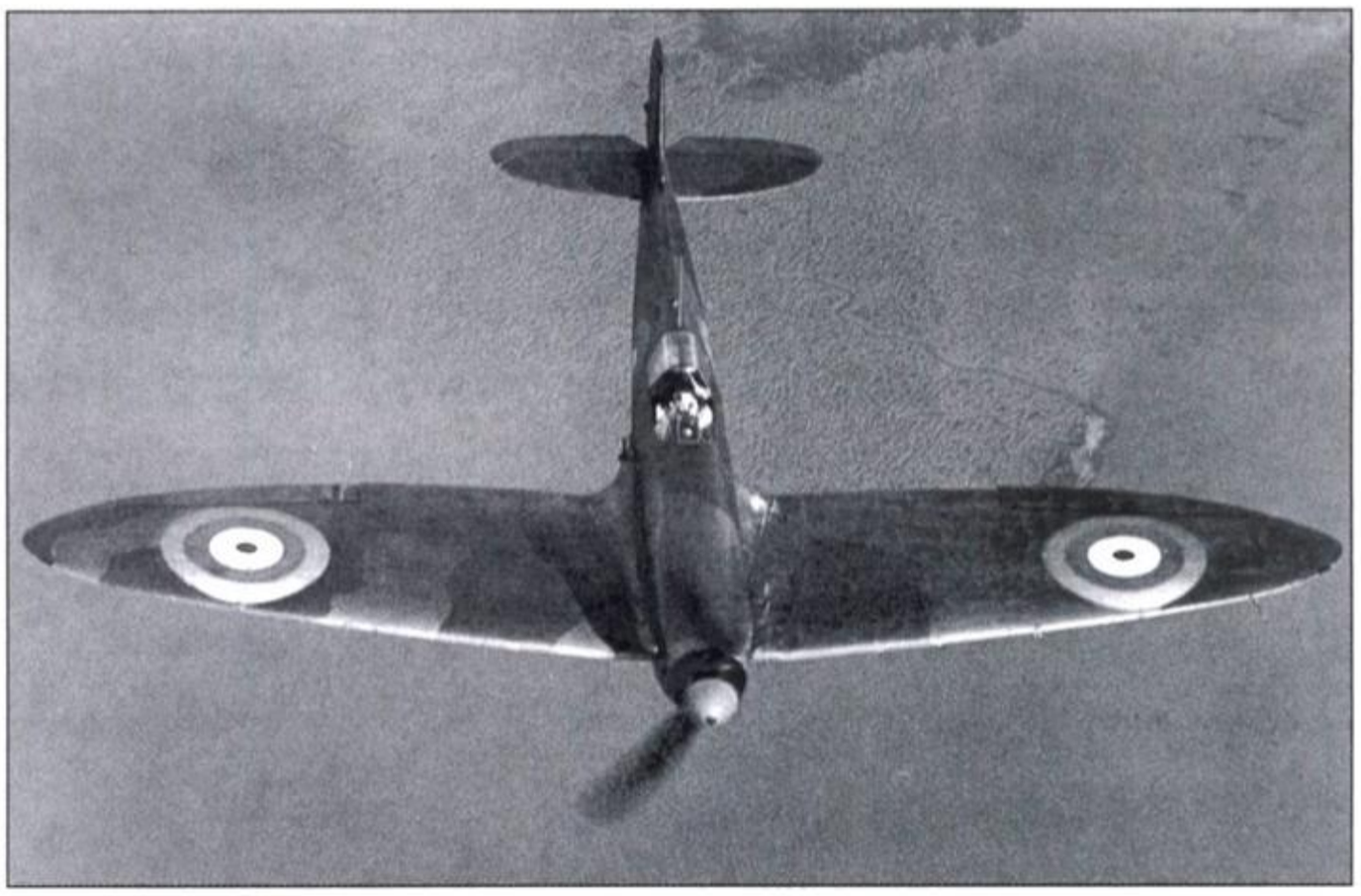
The Spitfire was designed primarily as a short-range home defence bomber-destroyer. Mitchell had not intended that it should engage enemy fighters, and during the so-called 'Phoney War' it never had to. All of that came to an abrupt end during May 1940, when the German army launched its powerful Blitzkrieg offensive against France, Holland and Belgium.

Spitfire fighters mounted their first operation over Europe on 12 May 1940. Six aircraft of No. 66 Squadron, accompanied by a similar number of Defiants of No. 264 Squadron, flew from airfields in East Anglia on a sweep over Holland. The force engaged a Ju 88 and inflicted some damage before it escaped inland. On the following day the two units flew a similar patrol, and for the first time Spitfires went into action against Messerschmitt Bf 109s. During a short but sharp engagement, four Ju 87s and a Bf 109 were shot down in exchange for five Defiants and a Spitfire.

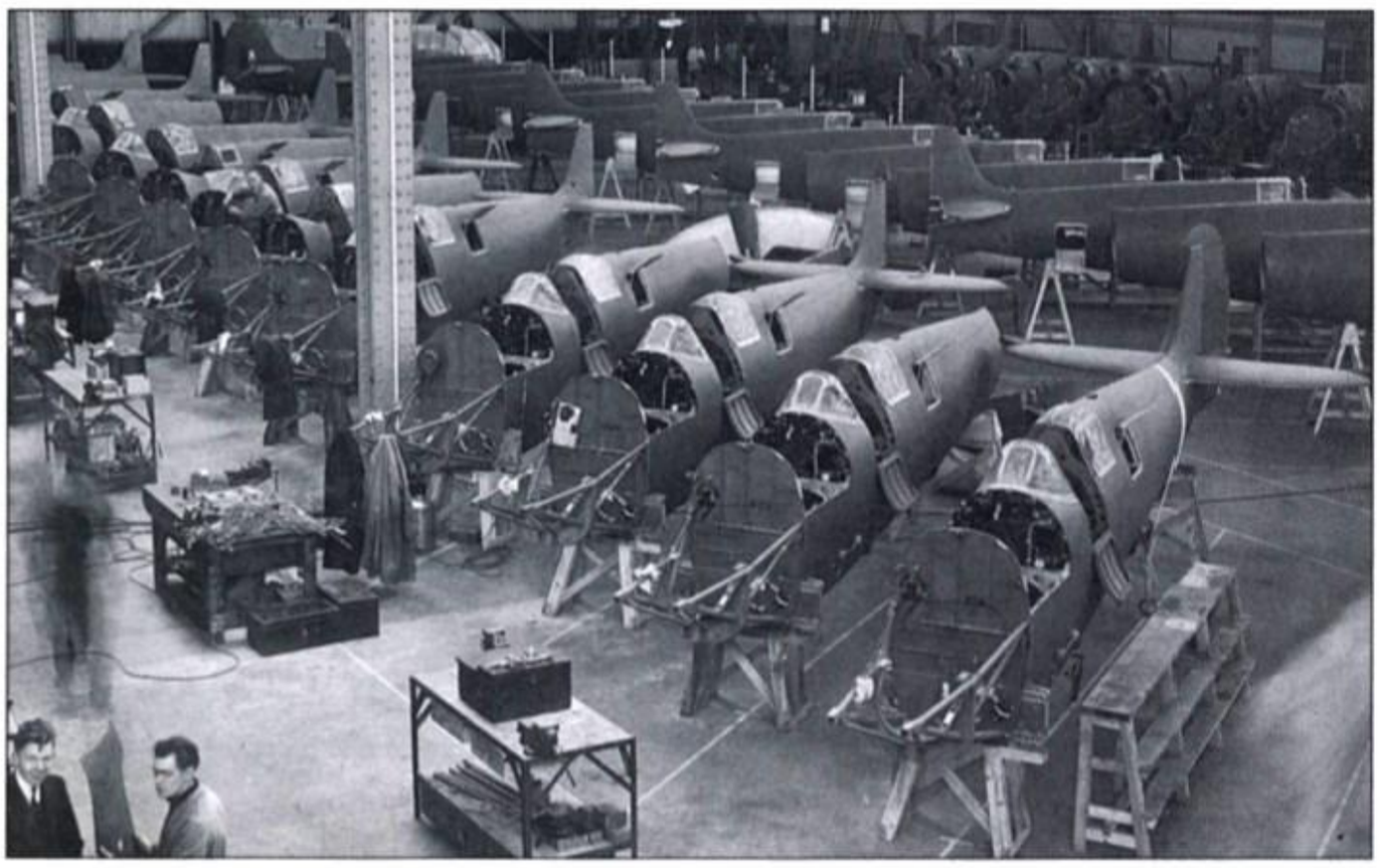
The first encounter

The Spitfire first encountered German aircraft *en masse* on 21 May 1940. By then, the rapid German advance into Belgium and France brought the war within range of Fighter Command units based in Kent. In the days that followed, Spitfires and Hurricanes flew numerous sorties to cover the evacuation of Allied troops from Dunkirk. Both sides suffered losses during the fierce air battles fought around the port. When the evacuation ended on 3 June 1940, Fighter Command had lost 72 Spitfires – nearly one-third of the front-line strength of these aircraft. It was

During repairs in September 1937, following the accident in March, the rebuilt prototype was finished in the standard RAF day fighter Dark Green and Dark Earth camouflage of the period. At the same time, the aircraft was fitted with ejector exhausts. They pushed top speed up to 347 mph (558 km/h) at 20,000 ft (6096 m).

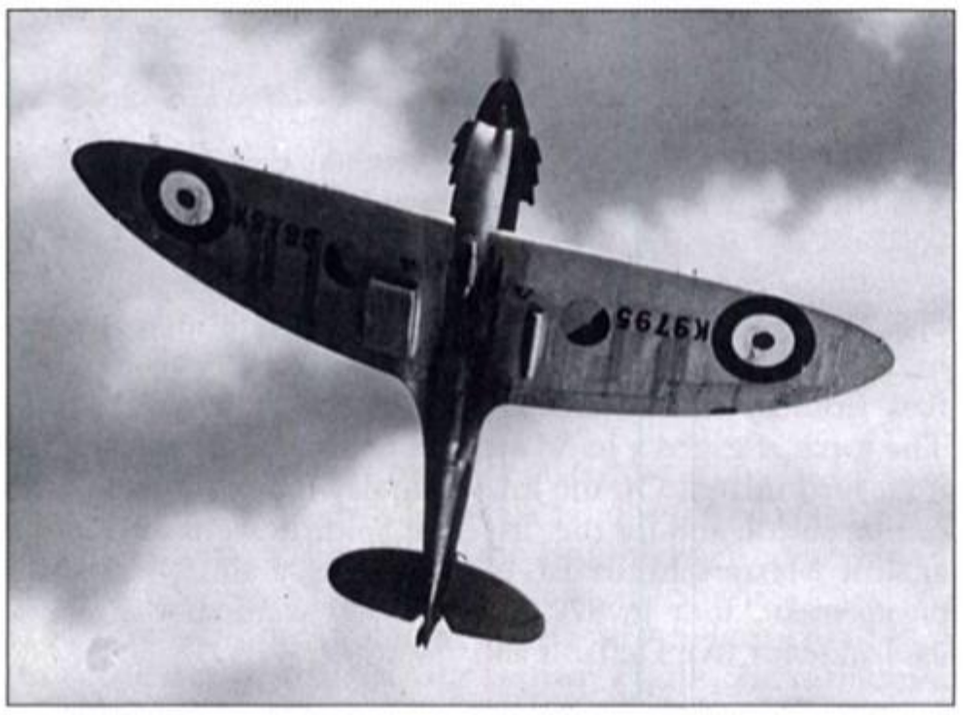


First production



On 3 June 1936 the Air Ministry placed the first order for 310 Spitfire Mk Is at an agreed cost of £1.395 million (though delays associated with manufacture of the wing leading edge pushed this price up to £1,870,242). With this substantial order, Supermarine, a relatively small company, faced an immediate production capacity problem. Eventually, two factories at Woolston and Itchen (both near Southampton) were equipped to produce the new fighter, final assembly taking place at Eastleigh. Despite initial opposition from Supermarine, much use was made of sub-contractors such as Folland, General Aircraft, Pobjoy and Westland. In September 1940 the two Southampton works were badly damaged by enemy bombs and production was then dispersed around 65 different factories in southern England. As well as the assembly line at Eastleigh, others were established at High Post, Keevil, Henley and Aldermaston. Apart from Supermarine, the other Spitfire manufacturers were the Castle Bromwich Aircraft Factory (CBAF), established by the Morris motor car manufacturer Lord Nuffield, Westland and Cunliffe-Owen. Meanwhile, the first Spitfire order was followed by two more for 200 and 450 aircraft for Supermarine, plus an order for 1,000 Mk II aircraft placed with CBAF in April 1938. Thus, by the time war had been declared, the RAF had ordered 1,960 machines.

Above: Taken at one of the two Supermarine factories near Southampton, this photograph shows Mk Is prior to their movement to Eastleigh for the fitting of wings and engines during final assembly.



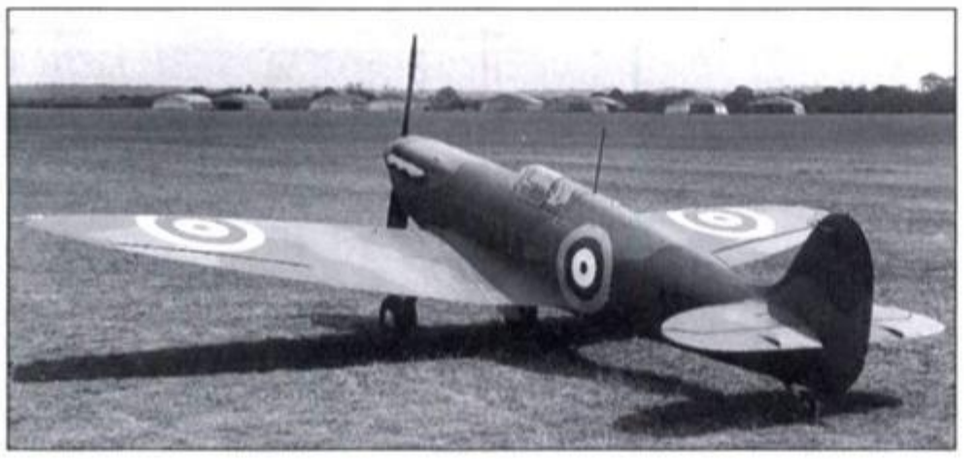
Right: The classic elliptical wing outline of the Spitfire is seen in K9795, the ninth aircraft off the Supermarine production line.

The 78th and subsequent production Mk I airframes, exemplified by P9450, the 601st Mk I (below), were fitted with a de Havilland three-bladed, two-speed variable-pitch propeller (de Havilland's constant-speed unit was not fitted to aircraft until mid-1940). Earlier aircraft, like the first production example (right), had a wooden fixed-pitch airscrew designed to perform most efficiently at service altitude. Other changes introduced during early production included the blistered cockpit canopy (to increase headroom), an improved radio (R/T) mast behind the cockpit and the glass plate 'bulletproof' windscreen.

as well the operation ended when it did, for the RAF had no choice but to accept this punishing loss rate as long as the evacuation continued; there could be no thought of abandoning the Royal Navy and the Allied troops to the mercies of the Luftwaffe.

Improvements to the Mk I

Between the entry into service of the Spitfire I, and the late spring of 1940, the fighter underwent a continuous process of modification. As a result of these changes, during the Battle of Britain the Spitfire was a considerably more effective fighting machine than it had been two years earlier.

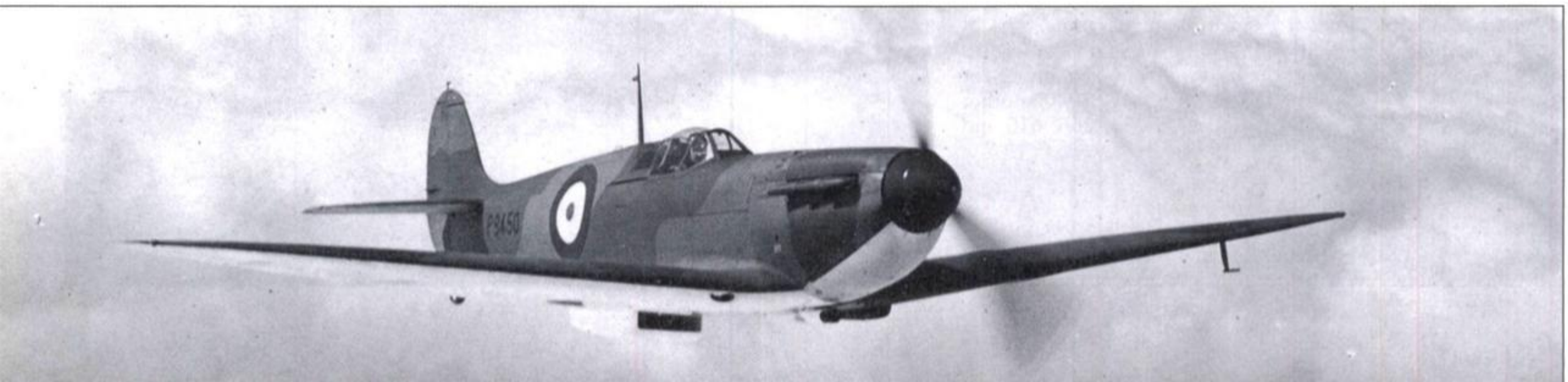


One of the first major changes made to the Spitfire was to fit a more effective airscrew. Fighters of the initial production batch used a two-bladed fixed-pitch wooden airscrew. The pitch setting was a compromise between coarse pitch for high speed, and fine pitch for good acceleration at operation. As a result, there were power losses at both extremes of the performance envelope. The 78th and subsequent production aircraft were fitted with de Havilland three-bladed two-pitch metal airscrew with two settings, one for low speed and one for high speed.

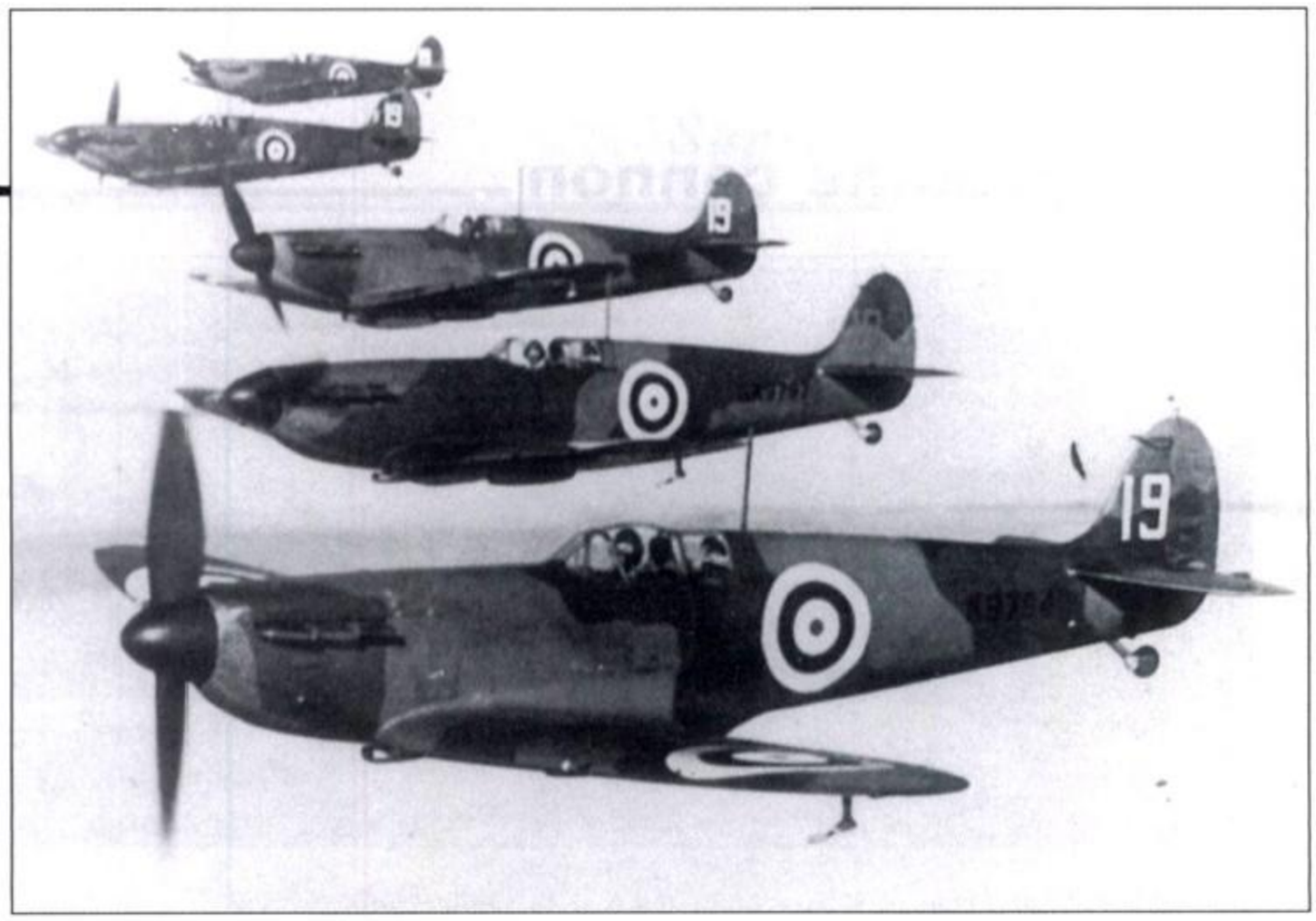
Performance increase

The new airscrew gave a useful improvement in performance. It reduced the still-air take-off run from 420 to 320 yd (384 to 292 m). It also increased the maximum speed from 361 to 365 mph (581 to 587 km/h) at 20,000 ft (6100 m), and raised the service ceiling from 31,000 to 34,400 ft (9450 to 10490 m). Shortly before the Battle of Britain there was a crash programme to fit constant-speed propellers (either the Rotol or the de Havilland type) to all front-line Spitfires. The constant-speed mechanism automatically adjusted the pitch of the blades to provide the optimum setting, so that the engine was always run at its most efficient speed of around 3,000 rpm. This modification gave a substantial improvement in the fighter's rate of climb, and made it easier to handle in combat.

During the spring of 1940, supplies of 100 octane petrol became available. The RAF modified the engines of front-line aircraft to use this fuel, instead of the 87 octane fuel used previously. The new fuel gave improved performance at heights up to the engine's full-throttle altitude (16,500 ft/5030 m). The higher octane fuel allowed an increase in supercharger boost from +6 lb to +12 lb, which the pilot could select by pushing the throttle 'through the gate' to the fully forward position. This emergency power setting



Above: This is Duxford on the occasion of No. 19 Squadron's Press Day in May 1939. Of interest in this photograph are the flat-topped canopies fitted to the second and fifth aircraft, the rest having the later bulged canopy, and the 'WZ' codes used by No. 19 from late 1938 to 1939.



Above: This was among the first official air-to-air photographs taken of the new aircraft, on 31 October 1938 from aboard an RAF Blenheim. The lead Spitfire was flown by Sqn Ldr Henry Cozens. Initially, No. 19's aircraft carried the unit's number on their tailfins.

Service entry, 1938

No. 19 Squadron, RAF had always been a single-seat fighter squadron. Formed from the nucleus of No. 5 Reserve Squadron, the unit was formed and equipped with BE.12s in June 1916. However, the BE.12s proved unsuitable as fighters and were replaced by Spad VIIs from December. In June 1918 Sopwith Dolphins were employed, serving until the unit was disbanded in 1919. No. 19 was based at Duxford, Cambridgeshire upon reformation in 1923, as a fighter flight attached to No. 2 Flying Training School. It achieved full squadron status on 1 June 1924, equipped with Sopwith Snipes. Grebes, Siskins, Bulldogs and Gauntlets were among the squadron's equipment in the 1920s and 1930s, before becoming the first unit to fly the Spitfire from August 1938. No. 66 Squadron, formed at Duxford from 'C' Flight of No. 19, followed in November.

With unusual grey serial numbers, this aircraft carries the markings of No. 66 Squadron, the second unit equipped with the type. This machine is equipped for gunnery practice with a gun camera fitted atop the starboard wing. During this period (early 1939), the serial number was not often carried. When it was displayed, it tended to be applied in small black figures on the tail fin.

put a great strain on the engine, however, and it could be used for a maximum of five minutes only. The new facility increased the fighter's maximum speed by 25 mph (40 km/h) at sea level and 34 mph (54 km/h) at 10,000 ft (3000 m). It also gave a useful improvement in climbing performance between sea level and the full-throttle altitude.

The early production Spitfires carried no armour protection for the pilot or vulnerable parts of the aircraft. The value of such protection soon became clear, though there were limits to the amount that could be carried without incurring an unacceptable weight penalty. To protect the pilot's head from rounds coming from ahead, a thick slab of laminated glass was mounted on the front of the windscreen. Also, the upper fuel tank received a 3-mm (0.12-in) thick cover of light alloy, to deflect small calibre rounds striking at a shallow angle. Later, a 73-lb (33-kg) sheet of steel plate was fitted behind the pilot's seat to protect his head and back against rounds fired from behind.

Early in 1940, Spitfires were fitted with IFF (Identification Friend or Foe) equipment. This transponder produced a distinctive coded response on British radar screens, thereby providing positive identification in confused tactical situations. The facility greatly improved the quality of British fighter control during the large-scale actions that summer.

Putting on weight

The first production Spitfire I tipped the scales at 5,819 lb (2639 kg) and its maximum speed was 362 mph (583 km/h) at 18,500 ft (5640 m). In the summer of 1940 the all-up weight of a fully modified Mk I Spitfire was about 6,150 lb (2789 kg) and its maximum speed was about 350 mph (563 km/h) at 18,500 ft (5640 m). Yet, as has been said, despite the drop in maximum speed, the later aircraft were more potent fighting machines than those built initially.

Although the 0.303-in (7.7-mm) Browning gun was reasonably efficient against unarmoured aircraft, it was

First squadron

Spitfire Mk I
Delivered to No. 19 Sqn on 27 September 1938, K9795 was the 10th production Spitfire. The unit's number was carried on the tail; the colour varied according to the flight with which the aircraft flew. A white '19' is believed to have denoted the squadron commander's aircraft. 'High visibility' markings were hurriedly replaced by more sombre marks after the Munich Crisis.

Troublesome cannon

Above: This frontal view of K9787 shows the arrangement of the eight Browning machine-guns with which most Spitfire Mk Is were equipped. These weapons had their own fair share of problems; using them at altitude was impossible until a satisfactory method of gun warming was devised.

relatively ineffective in penetrating armour or puncturing self-sealing fuel tanks. The obvious answer was to change to a heavier-calibre weapon, and the RAF had already selected the French 20-mm Hispano Suiza Type 404 cannon. In July 1939 the prototype cannon Spitfire, fitted with two Hispano Suiza-manufactured weapons, underwent tests at Martlesham Heath. During its firing trials in the Spitfire, the cannon suffered frequent stoppages. The weapon functioned reliably in the French Morane 406 fighter, where it was mounted on top of the engine and fired through the propeller hub. That produced a rigid installation, in which the mass of the engine absorbed the hefty recoil forces. In the Spitfire, in contrast, the cannon were placed in less rigid mountings in the wings. If the British fighter was pulling *g* at the time of the firing, the wings flexed and rounds were liable to misfeed, causing a stoppage. If the cannon on one side jammed, the unbalanced recoil forces on the other side made accurate aiming almost impossible. In the spring and early summer of 1940, RAF engineers devised a series of changes which appeared to resolve the problem. A small batch of Spitfires, each armed with two British-built Hispano 20-mm cannon and designated Mk IBs, entered service with No. 19 Squadron in June 1940.

Below: Spitfire Mk I L1007 became the Hispano Suiza 20-mm cannon-armed prototype in June 1939 and was tested at Martlesham Heath the following month. Though lighter than the Browning-armed Mk I, the Mk IB (as service examples were known) was no faster due to the extra drag caused by the cannon installation. The first Mk IBs used just two guns but this was deemed insufficient for combat. Later aircraft with the 'B' wing featured two pairs of Brownings outboard of the cannon.

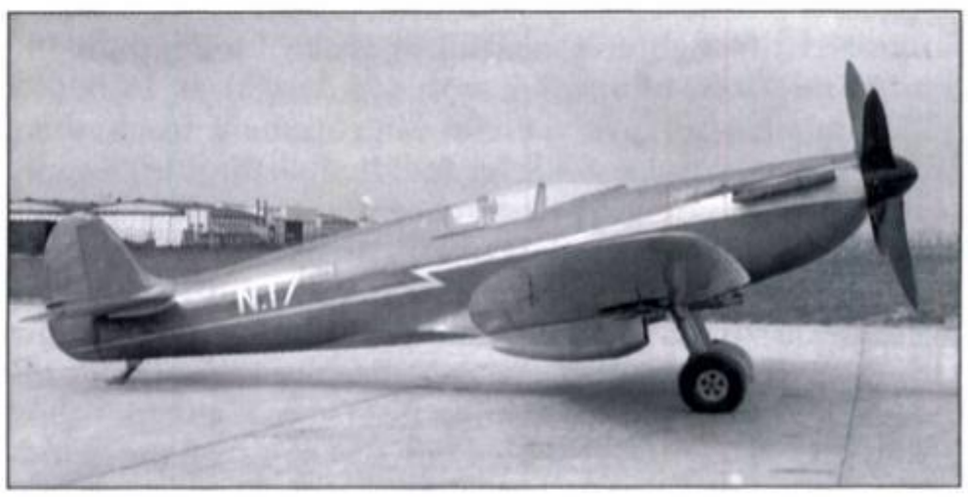
Battle of Britain

The Battle of Britain has been covered in great detail in numerous other publications, so this account is restricted to an outline of the salient features of the Spitfire's performance during that epic action.

The RAF had expected great things from its cannon-armed Spitfires, but when No. 19 Squadron went into action in August 1940 the weapon's performance was abysmal. During the combat on 16 August, both cannon functioned properly on only one out of the seven Spitfires that engaged the enemy. On 19 August it was none out of three, on 24 August it was two out of eight and on 31 August it was three out of six. Following these embarrassing failures the squadron's commander, Squadron Leader R. Pinkham, complained to his superiors: "In all the engagements so far occurring it is considered that had the unit

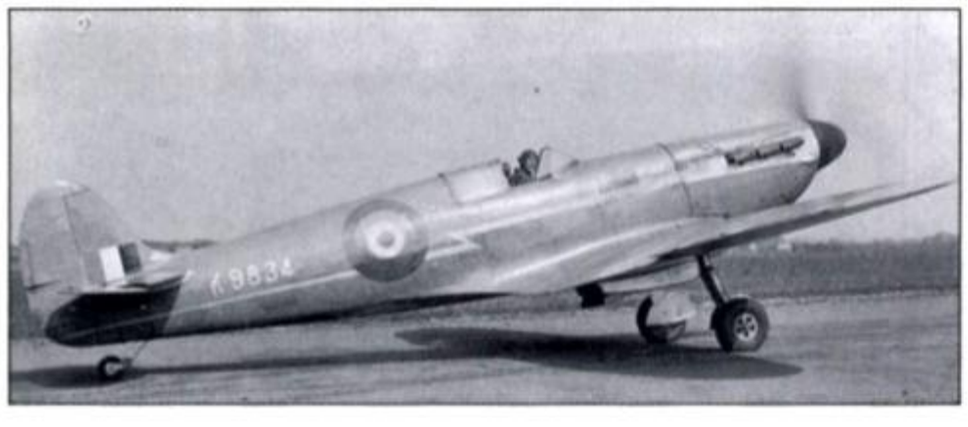
'Speed Spitfire'

The possibility of building a Spitfire for an attempt on the world landplane speed record was mooted in the summer of 1937. At that time the Hughes H-1, flown by millionaire Howard Hughes, held the record with a speed of 567.115 km/h, not much more than the maximum speed of the prototype Spitfire – around 562 km/h (though the latter was achieved at altitude and speed record flights were restricted to 75 m altitude; K5054 was only capable of 467 km/h at sea level). Modifications would therefore be necessary, but it was felt that speeds of over 567 km/h were well within the Spitfire's capabilities. K9834, the 48th production Mk I, was taken from the production line and fitted with a Merlin II (Special) running on special fuel and rated at 2160 hp (1611 kW) for take-off. Driving a four-bladed fixed-pitch propeller, the engine also required a modified cooling system. Meanwhile, in November 1937, the existing speed record was raised by a modified Messerschmitt Bf 109 V13 to just under 611 km/h, and in June 1938 the Heinkel He 100 V2 had set a closed-circuit record of 634.59 km/h. The 'Speed Spitfire', as it was known, first flew on 10 November 1938, but by December the Air Ministry, convinced that the He 100 was about to take the record to about 725 km/h, decided to proceed only with the research and development aspects of the project. Flight testing continued into 1939, a top speed of 656.5 km/h being attained. By the end of March the He 100 V8 had touched 746.6 km/h and in April the Me 209 V1 took the record to 755.14 km/h, well beyond the abilities of the Spitfire at the time.



Above: Finished in a coat of highly polished dark blue paint with a silver 'lightning stripe', the 'Speed Spitfire' carried the manufacturer's Class 'B' registration N.17. Notable features of the aircraft were its more streamlined cockpit canopy, a slightly reduced wing span with more rounded wingtips, and the large wooden four-bladed propeller.

Below: The 'Speed Spitfire', seen at Eastleigh in early 1939, has a towing dolly under the tail and has had the radiator fairing under the starboard wing removed.



Left: By November 1940, K9834 had been fitted with a Merlin XII engine and a standard cooling system. In this form it was delivered to the RAF's Photographic Reconnaissance Unit (PRU) at Heston as a 'hack' aircraft. The aircraft is pictured here in March 1942, by which time it had been fitted with a PR-type curved windscreen and an early Mk I-type cockpit canopy. K9834 survived the war, only to be scrapped in June 1946.

Night-fighters

A night-fighting role was always envisaged for the Spitfire, even though the narrow track of the type's undercarriage made it unsuitable for night-time operations, except in bright moonlight. The Luftwaffe began small-scale night bombing of British targets on 5 June 1940; the first large attack came on the night of 18/19 June. From this date day-fighter squadrons, including those equipped with Spitfires, were assigned night patrol sorties, so-called 'cat's eyes' patrols, which were entirely reliant on moonlight and/or the skills of searchlight operators to hold a target in their beams long enough for a fighter to 'get a shot off'. There were a number of successful engagements during the second half of June, but the Luftwaffe soon learned its lesson and flew its bombing missions at higher altitudes, beyond the range of searchlights. Overall, night victories were few and 'kills' by Spitfire pilots even fewer. Modifications made to the aircraft involved in these primitive night interceptions were minimal. To shield the pilot's eyes from the glare of the exhausts during night flying, Spitfires were often fitted with 'blinkers' in front of the cockpit.

No. 72 Squadron was one of the units involved in the limited Spitfire night operations during mid-1940. Prior to being thrown into the fray over southeast England, the squadron was based at Acklington, with a night-fighter flight detached to Woolsington (today Newcastle Airport). On 27 June Flying Officer Thompson brought down a Ju 88 which had been caught in searchlights, one of the few Spitfire night kills.

been equipped with eight-gun fighters it would have inflicted far more severe losses on the enemy. It is most strongly urged that until the stoppages at present experienced have been eliminated, this squadron should be re-equipped with Browning gun Spitfires."

Headquarters Fighter Command accepted Pinkham's suggestion, and early in September the unit exchanged its cannon fighters for normal eight-gun Spitfires. The Hispano-armed Spitfire played no further part in the Battle of Britain.

Inadequate weapons

Because of these initial problems with the Hispano cannon, during the Battle the Spitfires and Hurricanes had to fight with a weapon that was inadequate against multi-engined bombers. There are several well-documented instances where German bombers regained friendly territory after taking more than 100 hits from 0.303-in (7.7-mm) ammunition. To achieve that concentration of hits probably meant that at least two British fighters had fired most of their ammunition into the bomber from short range.

The survivability of the German bombers was much enhanced by the self-sealing fuel tanks developed following combat experience in the Spanish Civil War. The light alloy tanks had a 1-cm (0.39-in) thick covering comprising alternate layers of vulcanised and non-vulcanised rubber. Surrounding the whole was an outer covering of leather. When a rifle-calibre round hit the tank it passed easily through this covering. When fuel started to leak through the hole, the petrol set up a chemical reaction with the non-vulcanised rubber, which caused the latter to swell and seal the hole. The carriage of fuel in self-sealing tanks saved many a German bomber from the fiery end that would otherwise have been its fate.

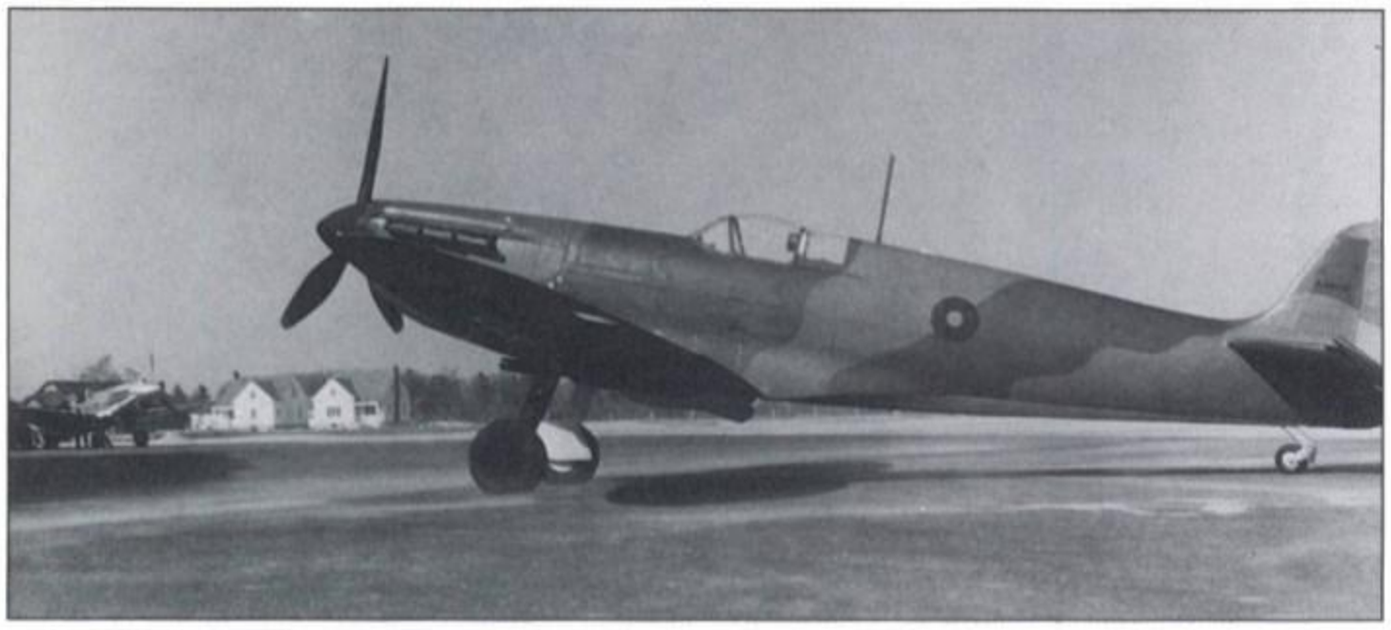
Early Spitfire victors

Spitfire Mk I
Flt Lt George Denholm, a flight commander with No. 603 'City of Edinburgh' Sqn, was among the Spitfire pilots in action on 16 October 1939, the day of the first successful engagement of a Luftwaffe bomber by the RAF. Denholm shared in the downing of a Heinkel He 111 and on 17 March damaged a Dornier Do 17 before being shot down in this aircraft, L1067. He later commanded No. 603 Sqn.

Spitfire Mk I
N3173/KL-N was flown by Plt Off Colin Gray of No. 54 Sqn when he claimed his first victory, a Bf 109E near Dunkirk on 24 May 1940. His Spitfire received major battle damage in the process, but Gray managed to nurse it back to Hornchurch. Plt Off Gray went on to become New Zealand's top-scoring pilot of the war, with 27 individual 'kills', all achieved on Spitfires.

Spitfire Mk I
Named *Kiwi*, N3183 was the aircraft in which New Zealander Plt Off Alan Deere of No. 54 Sqn downed aircraft on consecutive days (24 and 25 May 1940) while covering the Dunkirk evacuation. During this action he was credited with seven victories in just five days. N3183 was shot down on 9 July; its pilot, Plt Off A Evershed, was killed.

Spitfires abroad



Before the outbreak of World War II, there was considerable interest from various foreign powers in acquiring Spitfires. One of the first interested parties was Japan, in early 1937. Mitsubishi hoped to purchase a single example; had the deal gone through, the implications for a Pacific war could have been enormous. Orders were placed by, or licences granted to build Spitfires to, Belgium, Turkey, Holland, Yugoslavia, Switzerland, Lithuania and Estonia. The latter placed the first order, for 12 aircraft, in February 1939. Greece also ordered 12 and Portugal 15. France requested an example in early 1939 and, as an important friendly country, moved up the queue. Delivered to the Armée de l'Air in July 1939 it was the only Spitfire delivered overseas before the war. (One other Spitfire was packed for shipment to Poland in July 1939, but was diverted to Turkey after the Polish surrender. In June 1940 two aircraft of a Turkish order for 15 were also shipped.)

Not an export, but a Spitfire overseas none the less. Mk I L1090 was shipped to Canada soon after the war broke out and in May 1940 was flown for comparison against the USAAC's Curtiss XP-40 fighter prototype (in background, left) from the RCAF base at Uplands. Back on RAF charge by August, L1090 became an instructional airframe and was eventually written off in 1944.

Had a large numbers of cannon-armed Spitfires and Hurricanes been available to fight in the Battle, and had the cannon performed reliably, it is interesting to speculate how much more effective Fighter Command would have been. As it was, by resorting to 'overkill' on several occasions, the British fighters caused sufficiently heavy losses to the enemy bombers to force the Luftwaffe to abandon its daylight attacks on England.

Spitfire versus Hurricane

In recent years there has been controversy regarding the relative effectiveness of the Spitfire and the Hurricane during the Battle. As mentioned above, with their rifle-calibre machine-guns both types were deficient in firepower when they engaged enemy bombers. During the large-scale actions, Spitfires and Hurricanes achieved victories approximately in proportion to the number of each type taking part. The Spitfire's superior performance and its smaller size meant it was less likely to take hits, however. In major actions the Spitfires suffered an average loss rate of around 4 per cent of those engaging, while Hurricane losses averaged around 6 per cent.

With a serial in the HK-range, usually reserved for impressed and captured aircraft, this Spitfire has an interesting history. It was one of the two Spitfire Mk Is (P9566 and P9567) shipped to Turkey in June 1940. Both finished up at the fighter training school at El Ballah, Egypt in 1942, carrying the serials HK854 and HK856.

Due to their lower rate of attrition, the Spitfire units spent more days in action than those equipped with Hurricanes. On average, a Spitfire unit spent nearly 20 days in action during the Battle before it had to be withdrawn to reform. That compared with under 16 days for the fully-engaged Hurricane squadrons (the four Hurricane units that played little part in the action are not included in this calculation). With more days in action, the individual Spitfire units were able to gain more victories. The 19 Spitfire squadrons taking part in the Battle are credited with 521 victories, an average of just over 27 per unit. The 30 fully-engaged Hurricane squadrons are credited with 655 victories, an average of just under 22 per squadron. In combat the average victory-to-loss ratio for Spitfire units was 1.8:1, while that for fully-engaged Hurricane units was 1.34:1.

During the summer and autumn of 1940, work to cure the failings of the Spitfire's cannon installation continued at the highest priority. Only near the end of 1940, too late to play a major part in the Battle of Britain, were the problems finally eradicated. Yet even when the cannon did work properly, another problem remained. The 60-round magazine fitted to each Hispano weapon contained sufficient ammunition for only five seconds' firing. That was judged insufficient for normal air-to-air combat. Accordingly, the next batch of Spitfire IBs carried a mixed armament of two Hispano cannon and four 0.303-in (7.7-mm) machine-guns. It proved a good compromise, and in November 1940 No. 92 Squadron re-equipped with the new variant. To differentiate these aircraft from the rest of the Mk Is armed with eight machine-guns, the latter were redesignated as Mk IAs.

In June 1940, after lengthy delays, the huge Nuffield factory at Castle Bromwich near Birmingham at last began large-scale production of the Mk II Spitfire. Externally the new variant looked like the late-production Mk I, the main difference being the Merlin 12 engine developing an extra 110 hp (82 kW). The increase in power gave the Mk II a slight edge in maximum speed and climbing performance, compared with its predecessor.

In August 1940 the first Spitfire IIs were delivered to No. 611 Squadron based at Digby. In the following month Nos 19, 74 and 266 Squadrons also received the new

Armée de l'Air Mk I

Spitfire Mk I
Finished in RAF colours and carrying the manufacturer's B-class marking N.21, the 208th production Spitfire Mk I first flew on 25 May 1939. Flown across the Channel on 18 July, the aircraft was given the serial '01' and evaluated by French pilots who attained 363 mph (584 km/h) during tests. Though French reports suggested the aircraft was burnt by the authorities, photographs apparently taken after its discovery by German forces in Orléans in 1940 suggested otherwise.

Left: During the first months of the war, the national press made frequent visits to RAF fighter stations. This scramble, featuring Spitfires of No. 611 'West Lancashire' Squadron, based at Digby, was staged on 8 April 1940 – the last day of the 'Phoney War' – at RAF Drem, near Edinburgh. During the first six months of the war, Auxiliary Air Force units in Scotland had seen more combat than any other units in Fighter Command.

variant. The Mk II replaced the Mk I in several units, and the squadrons operating the newer variant concentrated in the southeast corner of England where the fighting was heaviest.

The initial batches of Spitfire IIs were armed with eight machine-guns. Later, small numbers were produced with the two cannon and four machine-gun armament and designated Mk IIBs. As with the Mk I, when that happened the machine-gun-armed machines were redesignated as Mk IIAs.

On the offensive

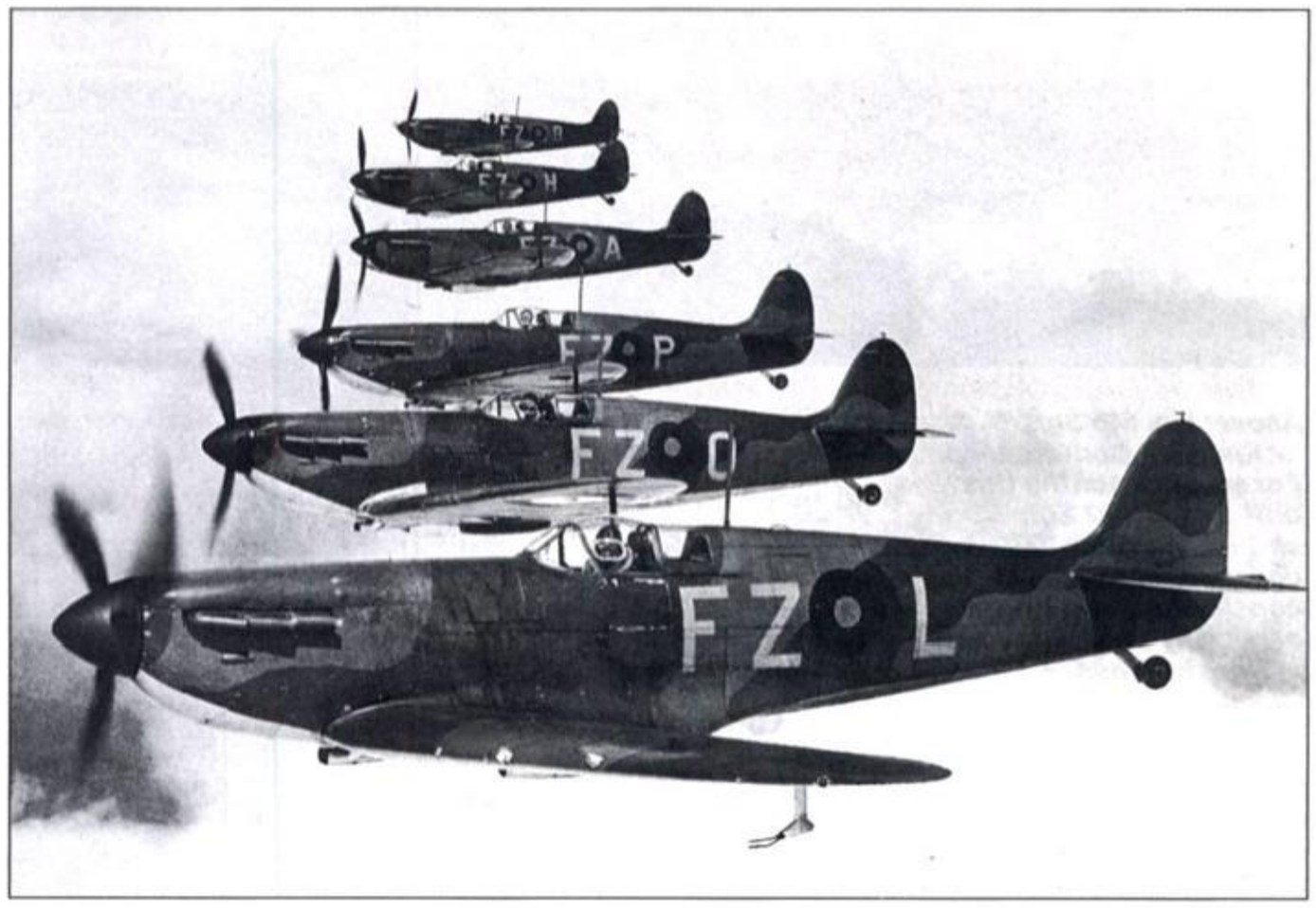
Early in 1941 RAF Fighter Command went over to the offensive. The new C-in-C, Air Chief Marshal Sir Sholto Douglas, termed the policy one of 'leaning forward into France' with the aim of drawing the Luftwaffe into action. On 9 January 1941 three squadrons of Spitfire Is flew an offensive sweep over northern France. The German fighter controllers chose to ignore the incursion, however, and it passed off without incident. The lesson was clear: sweeps by fighters alone would not bring the enemy into action. Like Fighter Command in the Battle of Britain, the Luftwaffe did not feel the necessity to engage sweeps by fighters flying alone.

On the following day the RAF made a more ambitious attempt to draw German fighters into action. The new type of operation, codenamed Circus, was centred around six Blenheim bombers attacking an ammunition dump near Calais. Seven squadrons of Spitfires and four of Hurricanes, a total of 103 fighters, escorted the bombers. This time there were scrappy fighter-versus-fighter actions and a Hurricane and a Spitfire were destroyed. German fighters suffered no losses.

In the weeks that followed, the Circus operations became a regular feature. For example Circus No. 5, on 26 February, involved an attack by 12 Blenheims on Calais harbour. The escorting force on that occasion comprised two squadrons of Hurricanes and four of Spitfires. Following 20 minutes behind came the Spitfire IIs of Nos 54 and 64 Squadrons, with the intention of engaging enemy fighters drawn up by the earlier incursion. One Spitfire in the follow-up force was shot down, the only aircraft lost on either side during the action.

The Mk V

During February 1941 the Spitfire V, the next major fighter version, made its appearance. The initial production aircraft were powered by the Merlin 45 engine which developed 1,515 hp (1130 kW) at 11,000 ft (3353 m) using +16 lb boost. The additional power gave it a substantial performance advantage over the Mk II. Apart from the new engine the other changes were relatively minor, and the new variant easily replaced the Mks I and II on the production lines. A few Mk VAs were built with eight 0.303-in (7.7-mm) machine-guns, but the majority were Mk VBs armed with the armament of two 20-mm cannon and four 0.303-in machine-guns.



A well-known photograph, taken just before the beginning of the war, of a well-known pilot and his charges. Spitfire Mk I K9906/'FZ-L' was allocated to Flg Off Robert Stanford Tuck upon delivery to No. 65 Squadron from the Supermarine factory in March 1939. Tuck became one of the first pilots to be credited with five victories. In April 1940, K9906 was transferred to No. 64 Squadron. After the Battle of Britain and a period with an Operational Training Unit (OTU), it was converted to PR.Mk III Type C standard and eventually struck off charge in May 1943.

The most ambitious daylight incursion by the RAF during 1941 took place on 12 August. An attacking force of 54 Blenheims delivered a low-altitude strike on the electricity-generating plants at Knapsack and Quadrath in western Germany. Six squadrons of Spitfires – Mks II, IIB and V – and one of Whirlwind twin-engined fighters provided close escort during the initial phase of the penetration. Five squadrons of Spitfires flew down the bombers' route almost to the limit of their radius of action, orbited for five minutes and then headed for home. The withdrawal cover force comprised three squadrons of Spitfire IIs and

RAF Fighter Command lost 72 Spitfires, nearly a third of its front-line strength, covering the evacuation of the British Expeditionary Force (BEF) through Dunkirk during late May and early June 1940. This represented the first large-scale commitment of Spitfires into combat. This machine was shot down on 6 June.

Above: No. 41 Squadron was among the units that formed No. 11 Group, Fighter Command in defence of London and southeastern England.

Above: No. 616 Sqn 'scrambles' from Kenley. For several months this unit and No. 92 Sqn shared the same 'QJ' code letters, leading to considerable confusion, especially among post-war historians.

Battle over Britain

The 310 aircraft in the first Spitfire Mk I order were all delivered by September 1939. A further order for 200 was placed in April; the last of them had been built by Supermarine by August 1940. In early July RAF Fighter Command's total assets were 347 Hawker Hurricanes, 199 Spitfires, 69 Bristol Blenheim night-fighters and 25 Boulton Paul Defiants. The Spitfires were all Mk Is equipping 19 squadrons, of which 14 were combat ready. Another 83 aircraft were listed as unserviceable. These statistics give some idea of the attrition rates suffered in training as well as combat. On 8 August the main Luftwaffe assault began and by 18 August 1940, the day on which the greatest number of aircraft were destroyed, 348 Spitfires were on strength, representing about a third of Fighter Command's modern single-engined fighters. Of these, 276 were serviceable.

Spitfire deployment, 14 September 1940

(Unless indicated, all units were equipped with Mk Is)

No. 10 Group

No. 152 Sqn	Warmwell
No. 234 Sqn	St Eval
No. 609 Sqn	Middle Wallop

No. 11 Group

No. 41 Sqn	Rochford
No. 66 Sqn	Gravesend
No. 72 Sqn	Biggin Hill
No. 92 Sqn	Biggin Hill
No. 222 Sqn	Rochford
No. 602 Sqn	Westhampnett
No. 603 Sqn	Hornchurch

No. 12 Group

No. 19 Sqn	Fowlmere
No. 64 Sqn	Leconfield
No. 74 Sqn	Coltishall (Mk IIs)
No. 266 Sqn	Wittering (re-equipping with Mk IIs)
No. 611 Sqn	Digby (Mk IIs)
No. 616 Sqn	Kirton-in-Lindsey, Ringway

No. 13 Group

No. 54 Sqn	Catterick
No. 65 Sqn	Turnhouse
No. 610 Sqn	Acklington

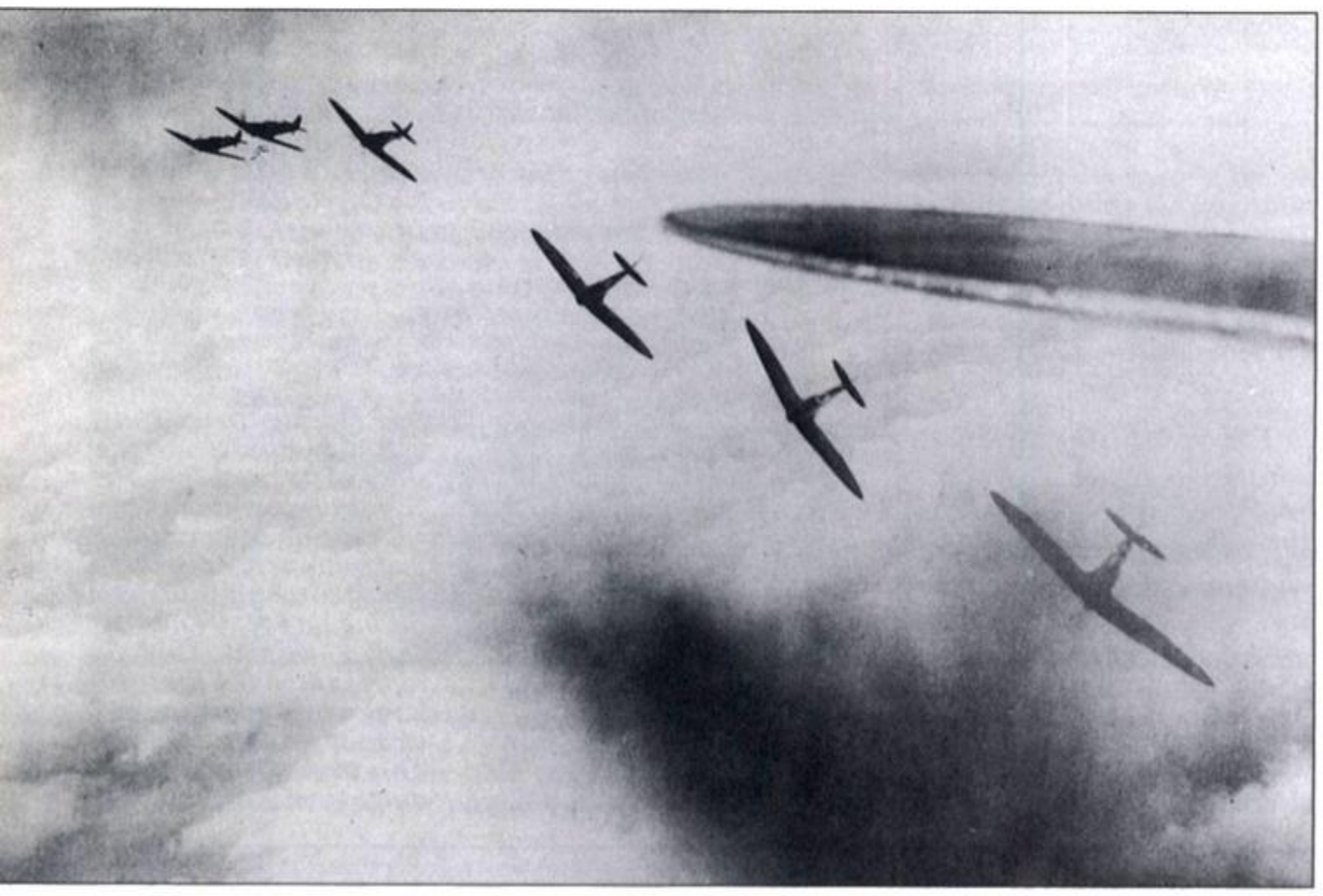
three more operating the Mk II (Long Range) version. German fighter and flak units reacted vigorously to this bold incursion, shooting down 10 Blenheims and inflicting damage on several others. Four Spitfires were lost.

Throughout 1941 the production of Spitfires increased steadily, allowing a major expansion of the force. From 19 Spitfire squadrons at the end of the Battle of Britain, Fighter Command moved to 46 squadrons equipped with Spitfires at the end of 1941.

Although the Mk V performed significantly better than earlier variants, it was outclassed by the Focke-Wulf Fw 190 which appeared in the autumn of 1941, providing the RAF with perhaps its biggest shock of the war. Fortunately for RAF Fighter Command, however, the new German fighter initially suffered engine overheating problems and was restricted in its operations. Also, the Luftwaffe was heavily committed on the Eastern Front, and could retain only a small force of fighters in the west. The Circus operations continued, although at a reduced frequency and at heavier cost than before.

The Mk V

The initial production versions of the Spitfire V, the VA and the VB, used Mk I and Mk II airframes with the minimum of change necessary to accommodate the Merlin 45 engine. The extra weight of the new engine and additional items of equipment reduced the fighter's strength factors, however. To restore them, the Mk V airframe was redesigned at several points to strengthen the structure. It was also fitted with the so-called 'Universal' wing, with provision to carry eight 0.303-in (7.7-mm) machine-guns, two 20-cannon and four machine-guns, or four 20-mm cannon. In practice, most aircraft carried the same armament as the Mk VB – two cannon and four machine-guns – although a few were fitted with four 20-mm cannon armament. The new sub-variant, designated the Mk VC, appeared in October 1941.



Left: Spitfires peel to port for the camera. Though the type had a marginal performance edge over the Bf 109 at altitude, it usually met its foe while climbing to intercept a bomber stream. At lower altitudes the two designs were on a par.

Right: This scene at Hornchurch sometime during the summer of 1940 features Spitfires of No. 222 Squadron ('ZD' codes) and No. 603 Squadron ('XT'). The steamroller in the background was used to flatten filled-in bomb craters.

Powerplant
The first 74 Spitfire Mk Is were powered by a Merlin II rated at 900 hp (671 kW) for take-off and 1,060 hp (790 kW); the rest had a Merlin III of similar rating. Fitted with a float carburettor, these engines were prone to 'cutting out' in negative *g* flight. To follow a diving enemy fighter a Spitfire was therefore obliged to perform a half-roll. It was not until December 1941 that a 'negative *g*' carburettor was tested by Rolls-Royce. They became standard on Merlin 50s fitted to late-build Spitfire Mk Vs.

Markings
Finished in the standard Dark Earth/Dark Green camouflage worn by the type since its introduction, this aircraft sports a standard 27-in (68.6-cm) fin flash, Type A fuselage roundels (with a yellow outer ring), Type B upper wing roundels and grey codes. During 1939 aircraft serial numbers were painted out on squadron aircraft for security reasons, but this appears not to have been a rigid rule; from early 1940, serials were left on service machines.

Night victories
On the moonlit night of 18/19 June 1940, during the first major night raid on England by the Luftwaffe, Flt Lt Adolf 'Sailor' Malan shot down two He 111s of KG 4 in quick succession in this aircraft. This remarkable feat was only possible with the help of searchlights, and earned Malan a Bar to his Distinguished Flying Cross.

Performance
Early Mk Is had a maximum speed of 362 mph (583 km/h) at 18,500 ft (5640 m) and were able to reach 20,000 ft (6100 m) in 9 minutes 25 seconds. Late-production machines were heavier due to the addition of armour and new equipment such as the coded IFF system. This brought top speed down slightly to 353 mph (568 km/h) at 20,000 ft (6100 m).

Spitfire Mk I versus Bf 109
During the Battle of Britain most of the fighter-versus-fighter combats took place in the height band 13,000 to 20,000 ft (3963 to 6100 m), because that was where the German bombers usually flew. At that altitude the Spitfire Mks I and II were about equal to the Bf 109E in capability. In the fleeting air combats that were the norm, tactical initiative far outweighed the relatively small performance differences between the two fighter types.

Spitfire Mk I No. 74 Squadron August 1940

No. 74 Squadron, RAF was based at Rochford and Hornchurch during the early phase of the Battle of Britain, before being withdrawn north to Kirton-in-Lindsey in mid-August. This aircraft, K9953, was on strength with No. 74 until at least early August, flown by the the unit's CO, Sqn Ldr D. F. 'Sailor' Malan, DFC and Bar, the South African ace who was instrumental in changing Fighter Command's tactics. In September, the unit re-equipped with Spitfire Mk IIs.

Gas detection
Fears that the enemy's arsenal might include gas (as it had in World War I) prompted the application of a painted gas detection square on the upper surface of the port wing. It changed colour if gas was present in the air.

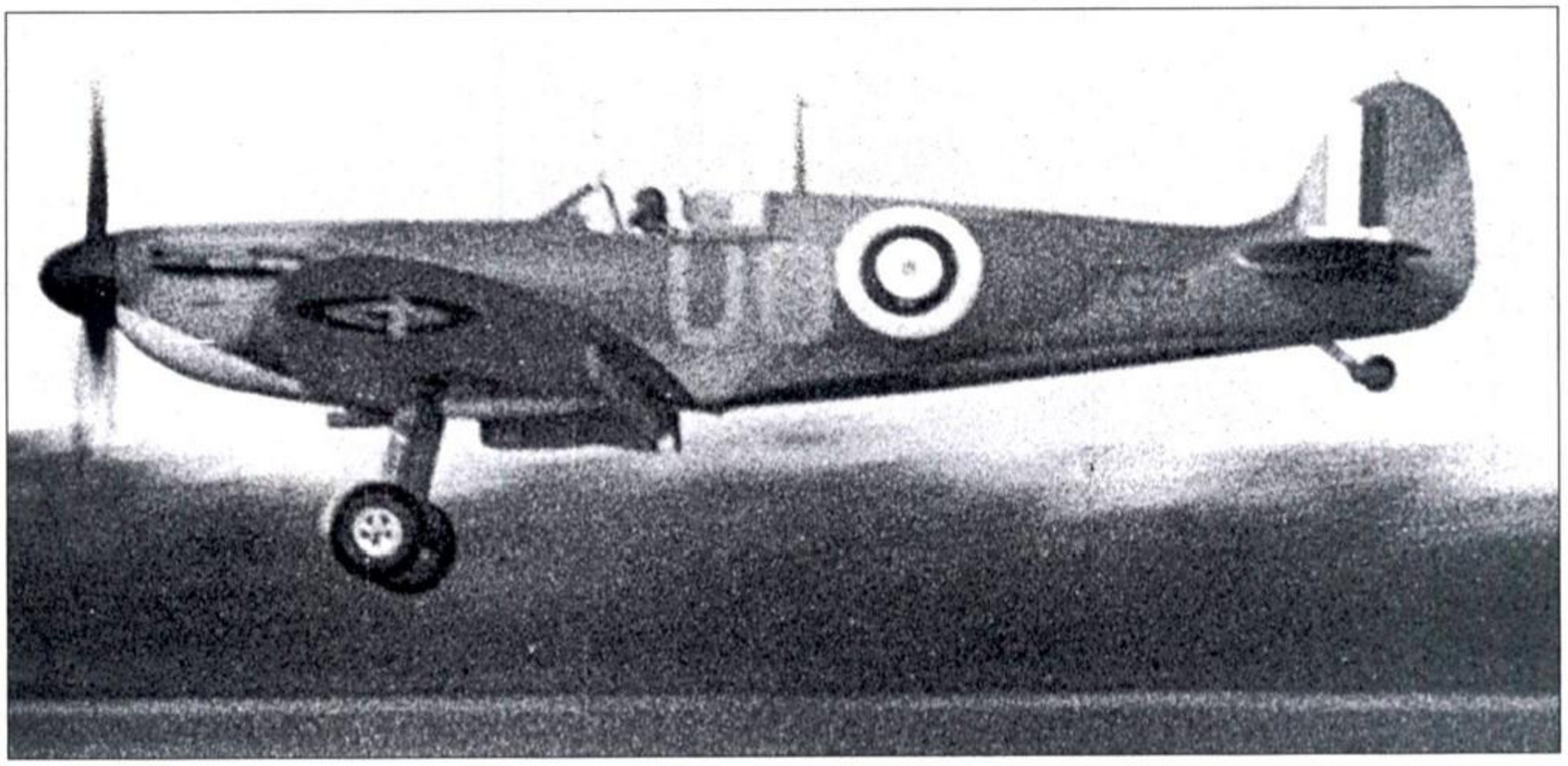
Armour
As the value of its protection became clear, armour was fitted around the upper fuel tank and behind the pilot's seat. This aircraft would also have had a thick laminated glass slab fitted to the front of its windscreen.

Undersurface markings
This aircraft wears the so-called 'Night and White' undersurface colours introduced, with variations, in late 1938/early 1939 and made the official standard from 27 April 1939 until 6 June 1940. From early June 1940 Sky was the standard undersurface colour but, with the frenetic pace of operations, application to service aircraft was a drawn-out process.

Armament
While the bulk of the Spitfire Mk Is, including this one, were fitted with eight 0.303-in machine-guns, the limitations of rifle-calibre ammunition against aircraft with armour and self-sealing fuel tanks were all too obvious. A small number of Spitfire Mk IBs (Browning-equipped aircraft were eventually redesignated Mk IAs) entered service with No. 19 Squadron in June 1940.

Above: Spitfire Mk Is of No. 610 ('County of Chester') Squadron, Auxiliary Air Force fly in formation in August 1940. In early June 1940 large Type A.I fuselage roundels and larger squadron code letters were introduced, though the lead aircraft in this formation has smaller codes, with the squadron and aircraft letters transposed. Several variations on a battle formation consisting of four three-aircraft sections were employed by Fighter Command during the battle. Sqn Ldr 'Sailor' Malan, CO of No. 74 Sqn and Spitfire 'ace', pointed out the weaknesses of the three-aircraft section, namely that the third aircraft in each section was a potential 'sitting duck'. His suggestion, adopted after the battle, was to employ three sections of four aircraft in line astern. Each section was then able to split into two two-aircraft elements when the action was joined.

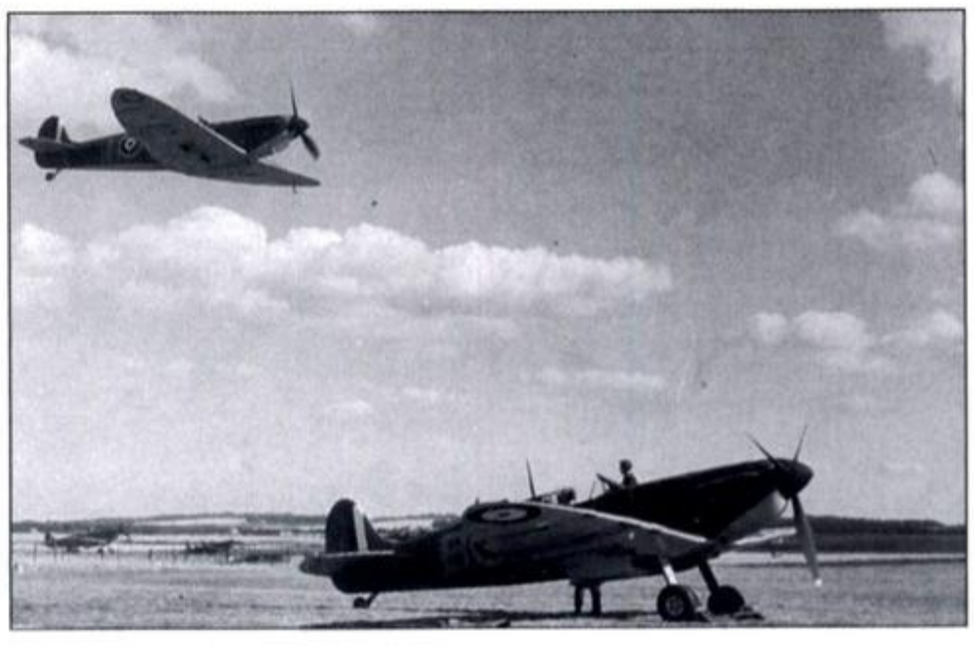
Above right: Photographs of the combatants' aircraft taken during the Battle of Britain are rare, those of Spitfire Mk IIs particularly so. Though not of good quality, this shot shows a Mk II of No. 266 Squadron (minus its individual code letter) about to land at Wittering in September 1940.



The Pressurised Mk VI

After the Battle of Britain there were fears that the Luftwaffe might be about to introduce new bomber types able to attack from altitudes above 30,000 ft (9150 m). To meet this perceived threat, a high-altitude interceptor version of the Spitfire was developed, the Mk VI. Based on the Mk V, the Mk VI was the first RAF aircraft to enter service fitted with a pressure cabin. The Merlin 47 engine fitted to this variant had an additional blower to supply air to the pressurised cabin, giving a pressure differential of 2 psi (13.79 kPa). Thus, when the fighter was at its maximum altitude of 37,000 ft (11280 m), the equivalent altitude in the cabin was 28,000 ft (8536 m). The Mk VI also had an extended-span wing with pointed tips, giving an additional 6.5 sq ft (0.6 m^2) of wing area. In the event, the high-altitude bombing threat never materialised, and production of this variant ceased after the initial order for 100 was completed.

Early in 1942 the Spitfire faced a new challenge. Britain's strategy in the Mediterranean hinged on the use of Malta as a base from which to interdict the Axis supply routes to Africa. Yet the besieged island was taking a fearful pounding from German and Italian bombers, and its continued



Duxford, home of the first Spitfire squadron, is seen as it appeared in October 1940. These two aircraft, unit unknown, are Mk IAs. Note the different-sized roundels on the undersurfaces of their wings.

Above: The RAF began to appreciate the value of dispersals after raids on RAF stations destroyed groups of parked aircraft. This photograph was taken by a crew member in a low-flying Luftwaffe Dornier Do 17 during a major raid on Kenley on 18 August 1940. The No. 64 Squadron Spitfire parked in a dispersal pen appears to have escaped major damage; 17 others elsewhere on the airfield were not so lucky, and 12 were destroyed.

Battle of Britain colours

Spitfire Mk I
During early June 1940, the undersides of RAF Spitfires were resprayed all-over Sky. Underwing roundels were only applied if the unit in question was expected to see combat over France. Dark Earth/Dark Green camouflage was retained. Flt Lt Crelin 'Bogle' Bodie (five 'kills' during the battle) flew this aircraft (X4321).

Spitfire Mk IB
No. 19 Sqn was issued with cannon-armed Spitfires for a brief period during the Battle of Britain. On 16 August R6776 was flown by Flt Sgt George Unwin who claimed a Bf 110 destroyed in the aircraft. Flown later by Nos 92, 316 and 306 Sqns, R6776 was written off in May 1942 with battle damage inflicted during a fighter sweep over France.

survival was in question. Malta's main air defence comprised a small force of Hurricanes, which were no match for the Bf 109Fs that the Luftwaffe had deployed to the theatre.

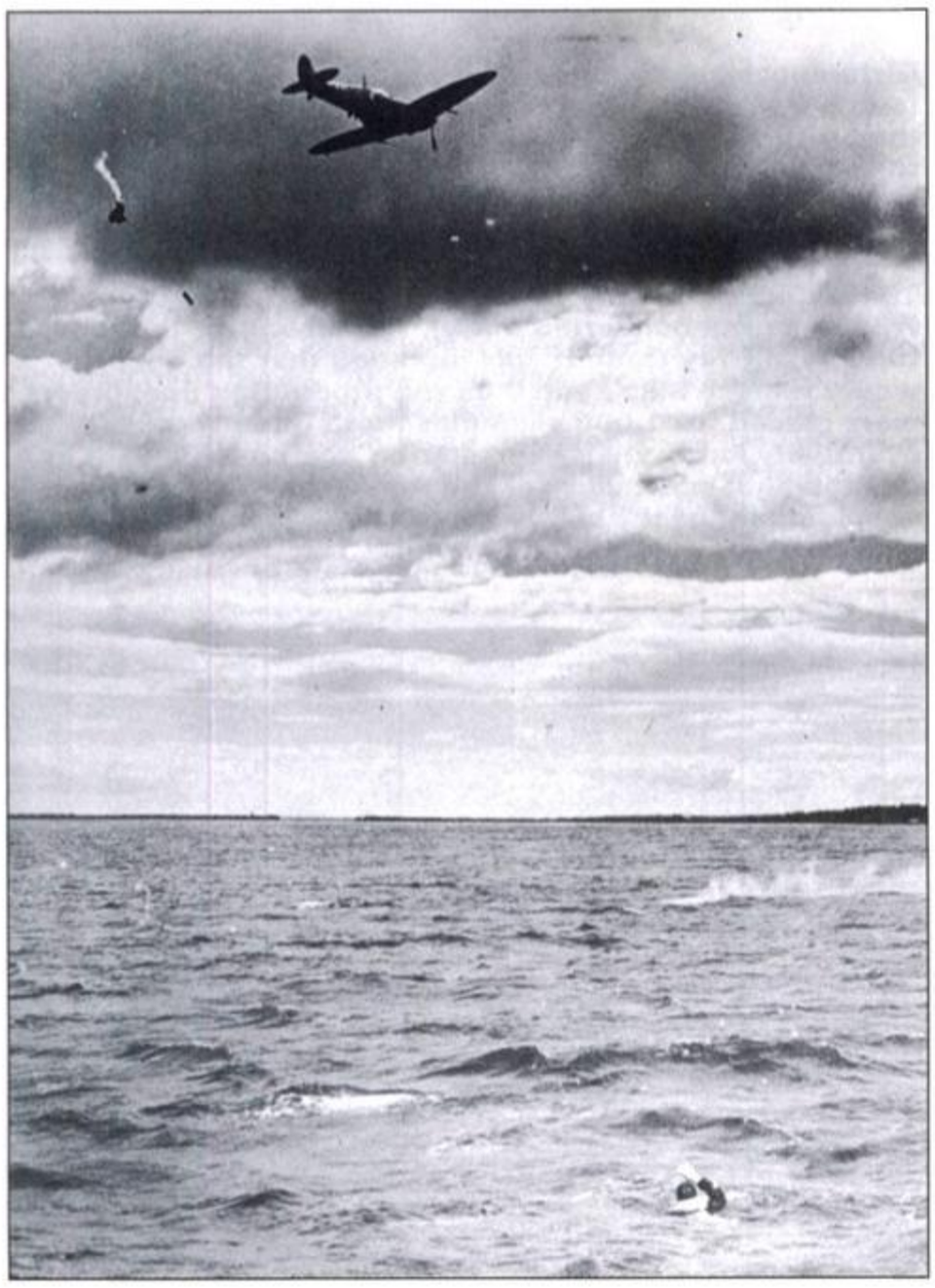
Spitfire to the defence of Malta

The obvious solution was to deliver a number of Spitfire Vs to the island, but there was no simple way of doing this. Malta lay 1,100 miles (1770 km) east of Gibraltar, far beyond the Spitfire's normal ferry range. With the Axis naval and air blockade in place, it was almost impossible to deliver the fighters by merchant ship. The Hurricanes already on Malta had been transported half way by aircraft-carrier, then they had taken off to fly the rest of the way to the island. From the nearest feasible flying-off point to Malta was 660 miles (1062 km), or about as far as from London to Prague. And that was still beyond the normal ferry range of the Spitfire.

For the Malta delivery operation, Supermarine designed a 90-Imp gal (410-litre) drop tank to fit under the fuselage of the Spitfire. Other modifications were necessary if the Spitfire was to operate successfully in the dusty conditions of the Middle East. Dust and sand entering the engine through the carburettor intake caused excessive wear, and would drastically reduce the life of the engine. To prevent this, a filter unit was mounted in front of the intake, in a beard-like fairing under the nose.

The first delivery of Spitfires to Malta took place on 7 March 1942, when 15 took off from HMS *Eagle* and flew to the island. Before the end of the month, the carrier completed two more delivery runs, to bring to 31 the number of Spitfires that reached the island.

The Spitfires arrived in the nick of time, for the Luftwaffe had stepped up its onslaught in preparation for the planned invasion of Malta. Heavily outnumbered, the Spitfires were pitchforked into a desperate battle for survival in which they took heavy losses. In April 1942 the US Navy carrier *Wasp* launched another 47 Spitfires for Malta,



Far left: Having marked the location with a smoke flare, the pilot of this Spitfire ASR.Mk II drops a dinghy to a hapless airman. These aircraft were fitted with Merlin XXs rated at 1,240 hp (925 kW) in place of the usual Merlin XII and a rack under the port wing for the carriage of marker bombs. Flare chutes on the underside of the aircraft carried rescue packs (comprising a dinghy and rations). This aircraft appears to have been converted from a cannon-armed Mk IIB. From mid-1944, Nos 276 and 277 Squadrons were equipped with Spitfire Mk Vs.

Air-Sea Rescue Mk IIs

During 1943, just over 50 Spitfire Mk IIs were converted as air-sea rescue aircraft for use mainly over the English Channel and Thames Estuary. Originally designated Mk IIC, these aircraft were redesignated Spitfire ASR.Mk IIs to avoid confusion with Spitfire fighters fitted with the 'C' wing. Nos 276 and 277 Squadrons, RAF were the main users of the ASR aircraft, though other rescue units (Nos 275, 278 and 282 Squadrons) were able to draw from a pool of these aircraft as necessary. 'AQ' was the code of No. 276 Squadron.

'Lop-sided Mk IIs'

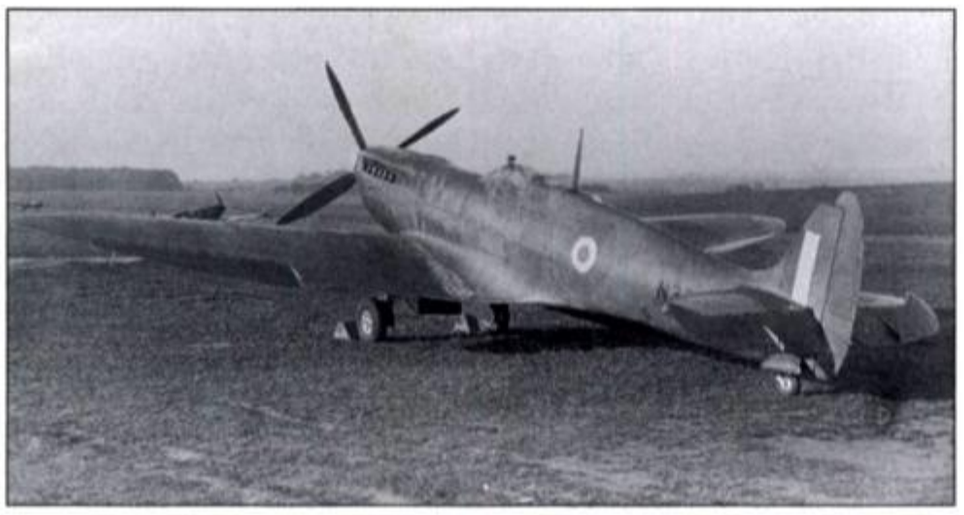
This is a Spitfire Mk IIA (long range) of No. 118 Squadron. The 40-Imp gal (182-litre) drop tank is visible on the port wing. The variant saw considerable use until the autumn of 1941, when the appearance of the Fw 190 brought an end to its activities.

Early in the war Supermarine made efforts to improve the Spitfire's limited radius of action. The drop tank was one possibility, but this was still an unproven concept and no such tank had been developed for any other British fighter. With the beginning of offensive sweeps and bomber escort missions over northwest Europe, early in 1941, the requirement became more urgent. About 60 Spitfire IIs were modified with a 40-Imp gal fixed tank fitted under the port wing, and were designated the Mk II (LR). Compared with the standard Mk II, the long-range version was 26 mph slower and took 2 minutes 48 seconds longer to climb to 20,000 ft; its low-speed handling characteristics were far less pleasant. However, with nearly half as much fuel capacity again as the standard Mk II, the long-range variant proved useful as a bomber escort. Several units flew this variant in combat from the spring of 1941 and Nos 19, 66, 118, 152, 222, 234, 501 and 616 Sqns have been identified as operating it at one time or other. When these squadrons moved to southeast England, they took over the Long Range Mk IIs from the units being withdrawn.

Operation Sunrise

Spitfire Mk IIA(LR)
This aircraft of No. 66 Squadron – with those of Nos 152 and 234 Sqns – provided escorts for Operation Sunrise the daylight attack on the German battlecruisers *Scharnhorst* and *Gneisenau* and the heavy cruiser *Prinz Eugen* in Brest harbour on 24 July 1941.

Right: Once Mk III development had ended, N3297 was fitted with normal-span wings and handed over to Rolls-Royce at Hucknall as a testbed aircraft. When it was next flown, in September 1941, it was a very different machine. A two-speed, two-stage Merlin 61 with multi-ejector exhausts had been installed, along with a four-bladed Rotol propeller to absorb the new engine's extra power. Trials with the re-engined machine at Boscombe Down began in January 1942 and demonstrated great performance improvements compared to earlier aircraft, laying the foundations for the Mk VII/VIII/IX series aircraft. Note that the retractable tailwheel fitted to N3297 when it was converted to Mk III status has been retained.



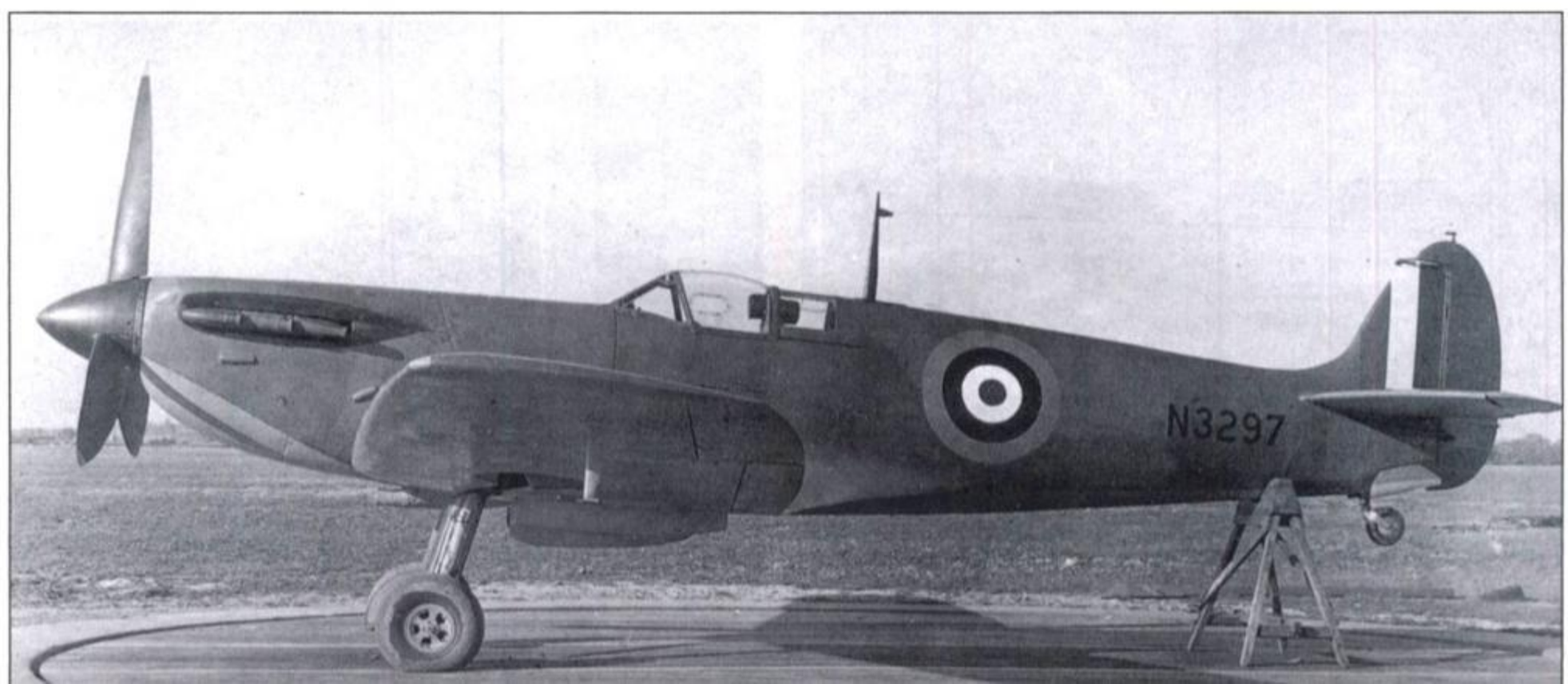
Below: Results of the service trials conducted with the Mk III prototype were reported to Air Marshall Dowding, C-in-C Fighter Command at the end of July 1940. He forwarded them to the Air Ministry, drawing attention to two "serious disadvantages in an otherwise excellent aircraft." They were its long landing run which, Dowding suggested, would prevent the aircraft from being used for night operations, and its square wingtips. The latter made the aircraft more difficult to differentiate from a Messerschmitt Bf 109, thought the Air Marshall. Accordingly, N3297 was to be fitted with Spitfire Mk I wings, but in the event they were not fitted until after Mk III development had been abandoned.

and all except one arrived. The air fighting was so fierce that after a few days most of these fighters had been destroyed in the air or on the ground.

The next operation to resupply Malta with Spitfires, Operation Bowery, was the largest of them all. Shortly after dawn on 9 May, *Wasp* and *Eagle* arrived within range

Stillborn Mk III

Differences between the Mk I and Mk II were relatively few; the Mk III was the first attempt to seriously improve the Spitfire's design. The most important changes were the installation of a 1,390-hp (1036-kW) (for take-off) Merlin XX equipped with a two-speed supercharger that offered improved performance at all altitudes, 'clipped' 9.3-m wings and a retractable tailwheel. On 16 March 1940 N3297, the only true Mk III (a second prototype, W3237, was a converted Mk V), was flown for the first time by Jeffrey Quill. It was intended that the Mk III would replace Mks I and II on the production line; orders were placed for 1,000 examples, but circumstances eventually led to their cancellation. Merlin XXs were in big demand, especially for the Hurricane Mk II, and development of the single-speed, two-stage Merlin 45 was about to overtake the Merlin XX.



'Eagle' Squadron

Spitfire Mk IIA
Plt Off William Dunn was the first pilot from an 'Eagle' squadron (manned by American volunteers) to score five victories and, therefore, the first American ace. His fourth and fifth victories were made in this aircraft (P7308) of No. 71 Sqn while escorting a force of Blenheims attacking the steel works at Lille.

and launched a total of 64 fighters. Sixty reached the island, which would be sufficient to change the course of the battle. Never again would the island be in such peril as it had been during the first week in May 1942. In the months that followed, Royal Navy carriers mounted eight more operations to launch Spitfires for Malta, delivering an average of 29 fighters on each.

Carrier escort

The use of aircraft-carriers to deliver fighters to Malta was an enormously expensive business, however. Each time these valuable warships put to sea, it was necessary to lay on a major fleet operation to protect them. At the request of the Air Ministry, Supermarine engineers were working on one of the most difficult challenges they were ever asked to face: to devise a way to extend the Spitfire's ferry range to 1,100 miles (1770 km), sufficient for it to fly from Gibraltar to Malta in a single hop. The solution was to fit a huge 170-Imp gal (772-litre) drop tank under the fuselage, a 29-Imp gal (132-litre) auxiliary tank in the rear fuselage and an enlarged oil tank under the nose. For the flights all non-essential equipment was removed from the fighter, and its armament was reduced to two 0.303-in machine-guns for self-protection. During October and November 1942, 17 modified Spitfires set out from Gibraltar to make the lengthy flight to Malta; all except one made it. That distance was about as far as from London to St Petersburg, a remarkable feat for an aircraft originally designed as a short-range interceptor. Upon arrival on Malta, the fighters had

The RAF began offensive sweeps over France in December 1940 as Fighter Command 'leant forward into France', and 'Circus' and 'Ramrod' bombing missions began the following month. No. 452 Squadron, RAAF, equipped with Mk IIs, was among the many Spitfire units to take part in these attempts to lure the Luftwaffe into battle.

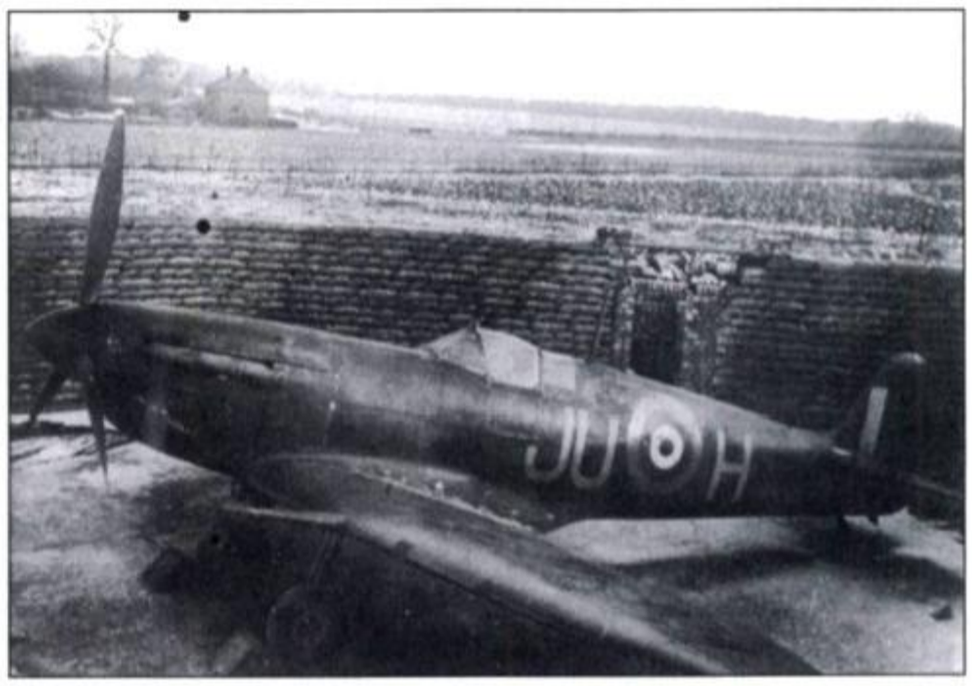
Mk V's debut, 1941

Right: X4257 (with 'Keep Out' chalked behind the cockpit to deter the curious) started life in August 1940 as a Mk IB aircraft, and later that month became the first Spitfire to be fitted with a standard 'B' wing (as opposed to twin cannon armament originally fitted to Mk IBs). In February 1941, Rolls-Royce at Hucknall fitted a Merlin 45, the aircraft becoming a Mk VB. Later in the year it was issued to No. 92 Squadron, the first unit to fly Mk Vs, for service trials. A crash suffered by this aircraft on 19 March after engine failure pointed to weaknesses in the de Havilland constant-speed propeller, which proved liable to freezing at altitude. This led to the adoption of the Rotol design, subsequently fitted to many Mk Vs. Around 150 other Mk Is and IIs were re-engined to Mk V standard to supplement new production.

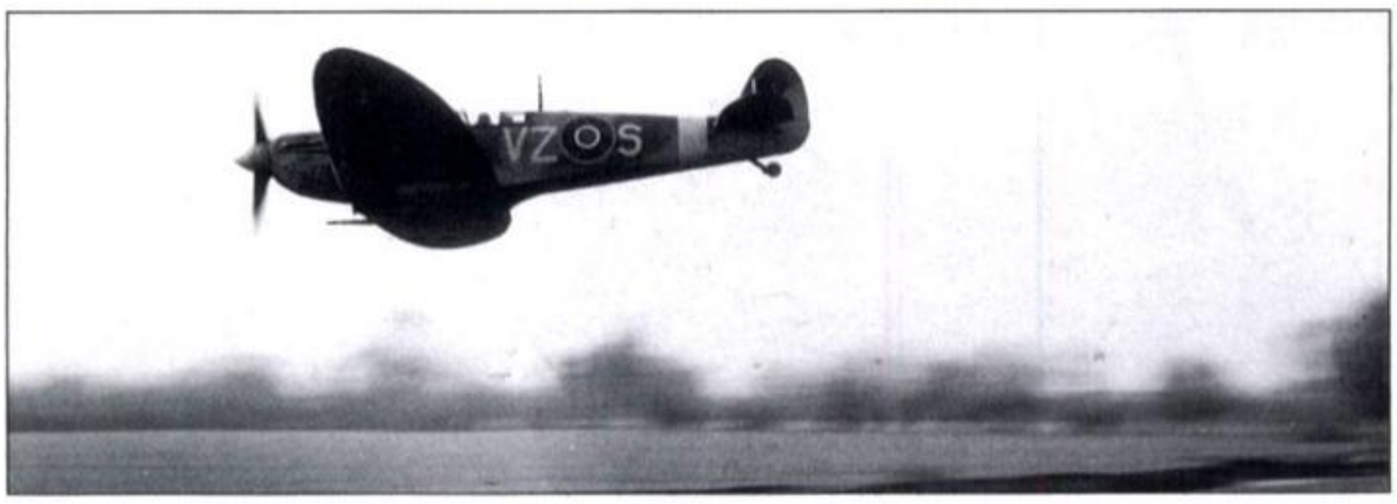
Left: At the request of USAAF commander Major General 'Hap' Arnold, two Mk VAs (R7347 and W3119) were shipped to Wright Field, Ohio during the summer of 1941. W3119 was transferred to NACA at Langley for an analysis of its flying qualities. An early Mk VC, AA963, followed in February 1942 aboard SS Evanger and was publicly displayed in Chicago in May. Here it is seen tied down at Wright Field, minus its wheels. AA963 was fitted with a DH propeller.

Right: No. 81 Squadron had a much varied history during World War II. After taking its Hurricanes to Russia with No. 151 Wing in 1941, the unit returned to Britain and reformed as part of the Hornchurch Wing with Spitfire Mk VBs, seen here. Engaged in sweeps over France, these aircraft carried the standard temperate RAF fighter camouflage scheme applied from May 1942. In late 1942 No. 81 stood down in preparation for overseas deployment, reforming in North Africa with Mk VCs. They were on strength only briefly, being replaced by Mk IXs during 1943. Towards the end of the year, No. 81 moved again, this time to the Far East with Mk VIIIs, which it flew until mid-1945, when they were replaced by Republic Thunderbolt Mk IIs.

Right: This view of a No. 92 Squadron Mk VB (converted from Mk IB R6923) shows the main recognition feature of the Mk V – the circular-section oil cooler under the port wing. On Mk I and II aircraft this had a half-moon section.

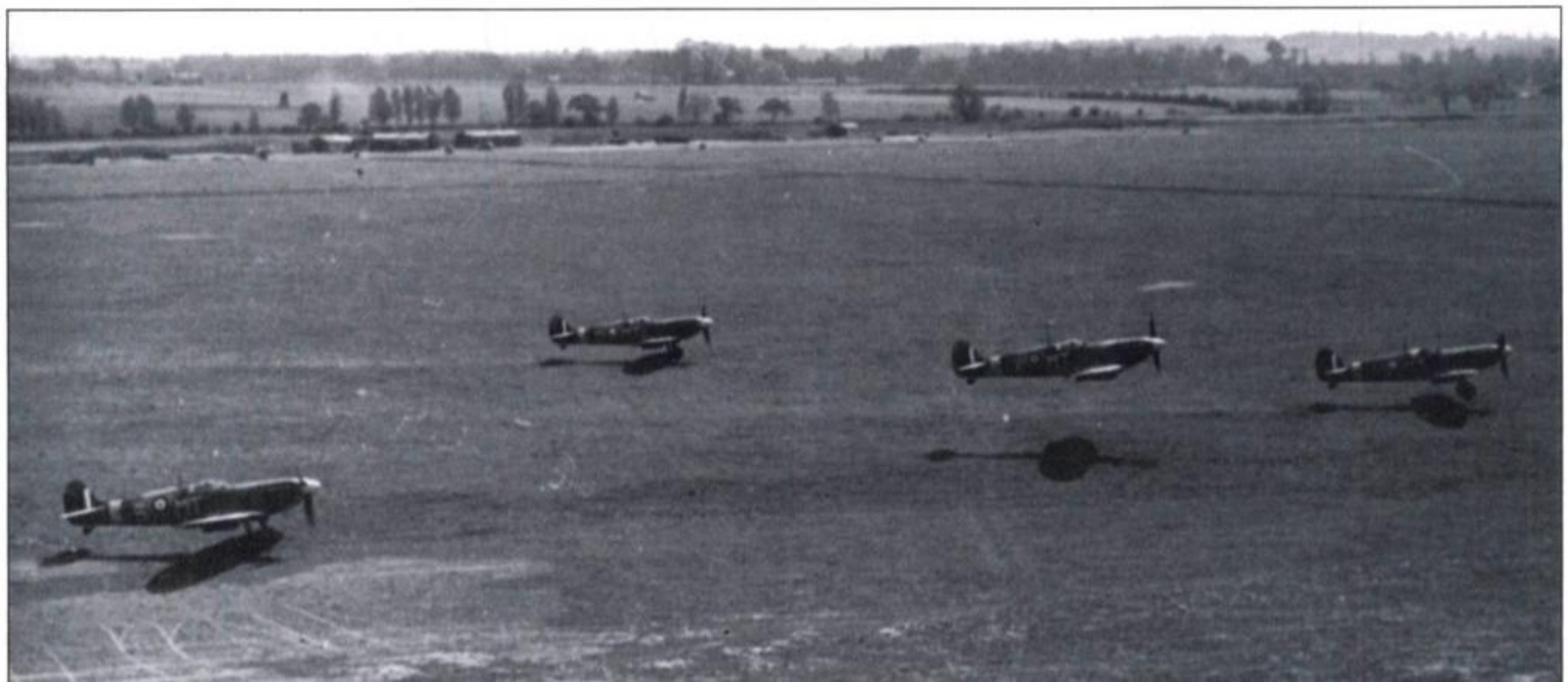


Above: In November 1941 there were fears that the Luftwaffe might resume its large-scale night attacks on Britain. Nos 65 and 111 Squadrons were temporarily assigned to the night-fighter role, their Spitfire VBs being painted matt black overall. It was intended that the Spitfires would intercept raiders illuminated by searchlights, and the units underwent training for the new role. In the event, the threat failed to materialise, and the squadrons reverted to their previous day-fighting role.



Below: A section of 'B' Flight, No. 122 Squadron leaves the ground at Fairlop, one of Hornchurch's satellites, during the summer of 1942. During August 1942, the unit's Spitfires were heavily involved in the abortive Dieppe landings, taking off at dawn on 19 August to cover the Allied landings. Its pilots spent an average of 7 hours 40 minutes in the air that day and claimed a Do 217 shot down and another two damaged, but, overall, the RAF's fighter cover proved inadequate.

Above: A No. 412 Squadron, RCAF Mk VB 'beats up' a ground position during an exercise. As well as 'Circuses', No. 412 (equipped with Mk VBs from October 1941) was also engaged in 'Rhubarbs' (small-scale fighter and fighter-bomber raids on targets of opportunity), 'Ramrods' (similar to a 'Circus', but with destruction of a target as the primary aim) and 'Rodeos' (fighter sweeps). The unit re-equipped with Mk IXs in October 1943.

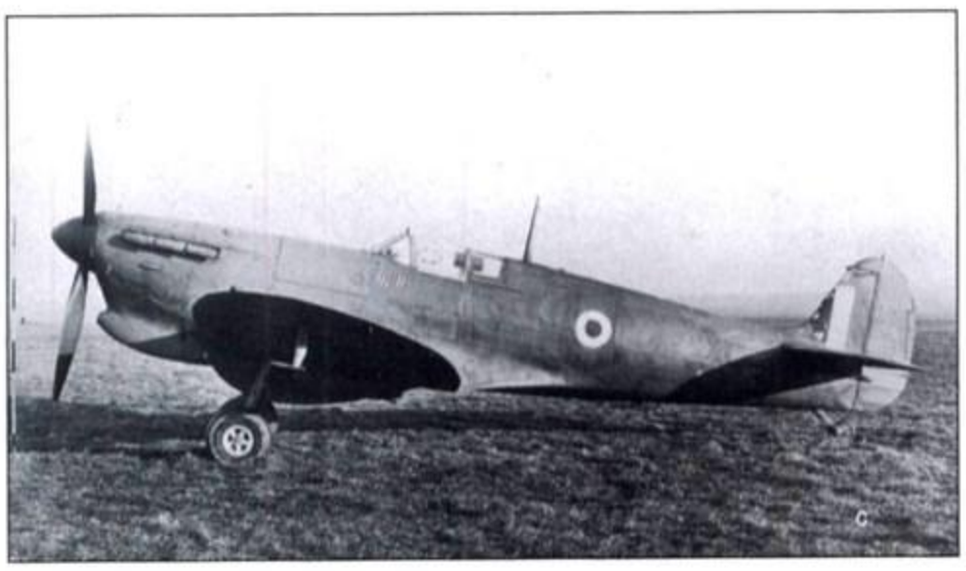


Overseas deployment

The Mk V was the first Spitfire variant to be sent overseas and was widely deployed in Europe, the Mediterranean, the Far East and the southwest Pacific.

Right: AB320 was the first Mk VB intended for overseas issue fitted with the Vokes filter on the production line. Most Mk Vs built after July 1941 were 'tropicalised'. This aircraft also carries a 90-Imp gal (409-litre) belly-mounted drop tank of the type used on the relief flights to Malta from aircraft-carriers.

Below: Ordered as a Mk I, but delivered as a Mk VA (only 94 of which were built), X4922 was the airframe selected for the trial installation of the Vokes tropical air filter in April 1941. Built with a Merlin 45 engine installed, X4922 was later re-engined with a Merlin 46 and was struck-off charge in late 1944.



the extra tanks removed and the rest of the armament fitted, to restore them to normal operational configuration.

The Mk V spreads its wings

Following those initial overseas deliveries of Spitfire Vs to Malta, others went to units in Egypt. When Allied troops moved into northwest Africa in November 1942, Mk Vs of the RAF and the US 12th Air Force provided air cover for their advance. Southeast Asia was next to receive these fighters. In each of those theatres, the Spitfires' arrival enabled the RAF and its allies to secure air superiority.

The only war theatre where the Spitfire failed to live up to its high reputation was that of Australia. In January 1943, three squadrons of Spitfire VCs arrived in the Northern Territory to provide a defence against attacks by Japanese aircraft. No. 54 Squadron was based at Darwin airport while Nos 452 and 457 Squadrons went to the nearby airfields at Strauss and Livingstone.

On 1 February, No. 1 Fighter Wing, RAAF became operational. The unit first went into action on 6 February, when two Spitfires of No. 54 Sqn engaged and shot down a Mitsubishi Ki-46 reconnaissance aircraft. The fast, high-flying 'Dinahs' had cruised over the area at will photographing targets, but from then their lives became much more difficult.

The defenders had problems of their own, however. Their airfields, in a remote corner of Australia, lacked the equipment to support sustained combat operations. As well as shortages of spare parts, there were problems with the Spitfires themselves. The fighter had never previously operated in a true tropical environment close to the equator. On the ground, the aircraft had to face extremely high temperatures and high humidity. At altitude, the Spitfires encountered air temperatures somewhat lower than any they had previously encountered. Those very low temperatures caused repeated failures of the constant-speed units (CSUs). The CSU controlled the pitch of the propeller blades,

Above: Tropicalised Mk VBs await spinners for their Rotol propellers and cannon for their wings prior to being issued to squadrons in the Mediterranean. Some have belly-mounted drop tanks for the inevitable ferry flight to their intended base in either Malta or North Africa. The broader blades of the Rotol constant-speed propeller can be seen in this view.

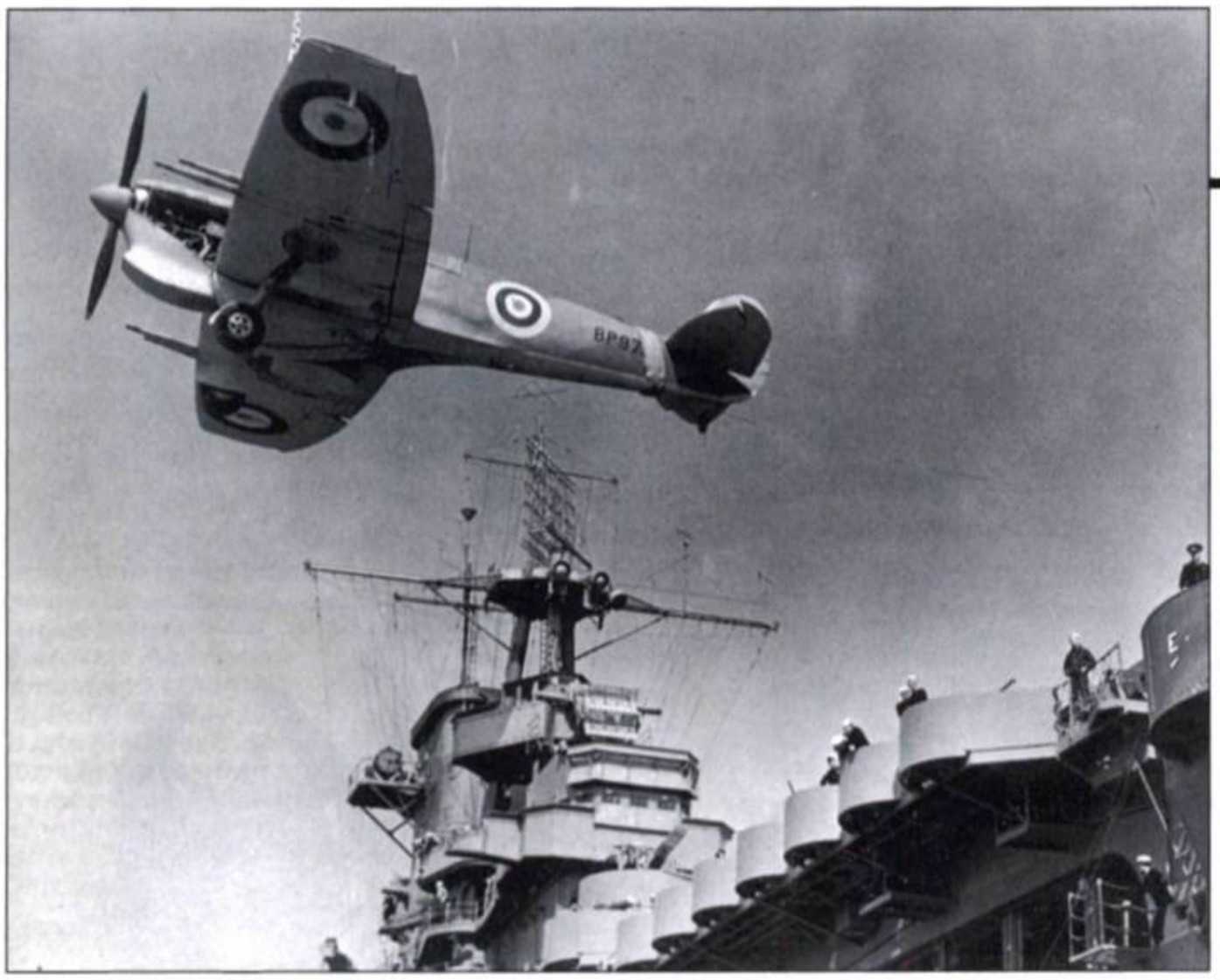
Below: In profile, the modified fairing around the nose-mounted oil tank was evident. The aircraft's guns were removed during ferry flights, save for two 0.303-in (7.7-mm) Brownings.

From Gibraltar to Malta

Left: As an alternative to the expensive use of aircraft-carriers to ferry Spitfires to Malta, Supermarine engineers were asked to extend the Spitfire Mk V's range to 1,100 miles (1770 km) to allow flights directly from Gibraltar to Malta. To this end, Mk VC BR202 was test flown with this huge 170-Imp gal (773-litre) belly tank and a 29-Imp gal (132-litre) auxiliary tank in the rear fuselage. To provide sufficient oil for the Merlin engine on such a long flight, a larger oil tank was fitted under the nose.

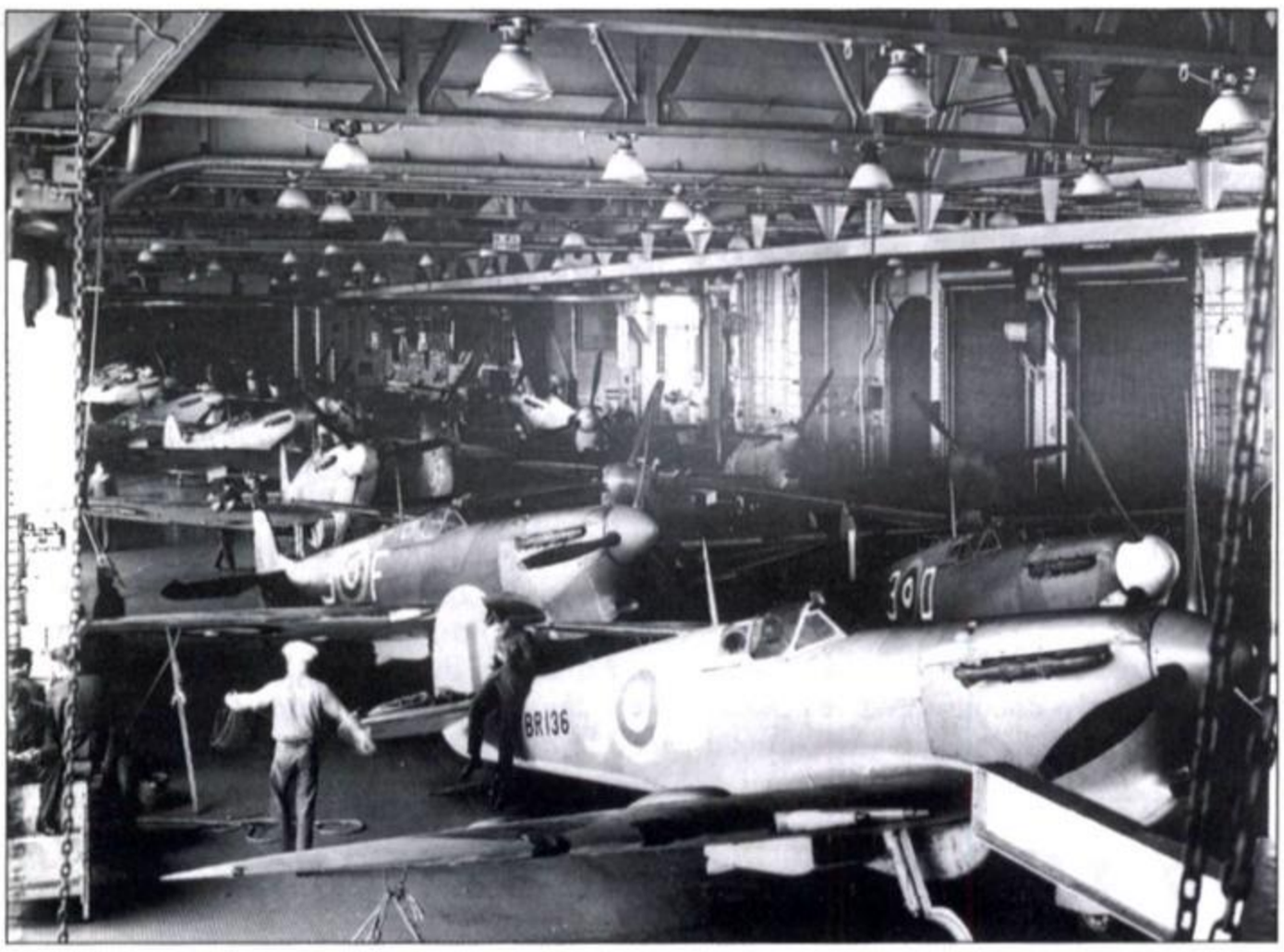
Operation Bowery

Representing the first deployment of Spitfires overseas, the reinforcement of Malta began in March 1942. Three groups of Mk VBs, totalling 31 aircraft, were flown the 660 miles (1062 km) from the carriers HMS *Eagle* and *Argus* to the island, whose defence against Luftwaffe Bf 109s was entrusted to outclassed RAF Hurricanes. Forty-six Mk VCs followed in April, flown from the US carrier *Wasp* by pilots from Nos 601 and 603 Squadrons. The biggest of these operations was codenamed Bowery and took place on 9 May, when 60 aircraft were successfully delivered.



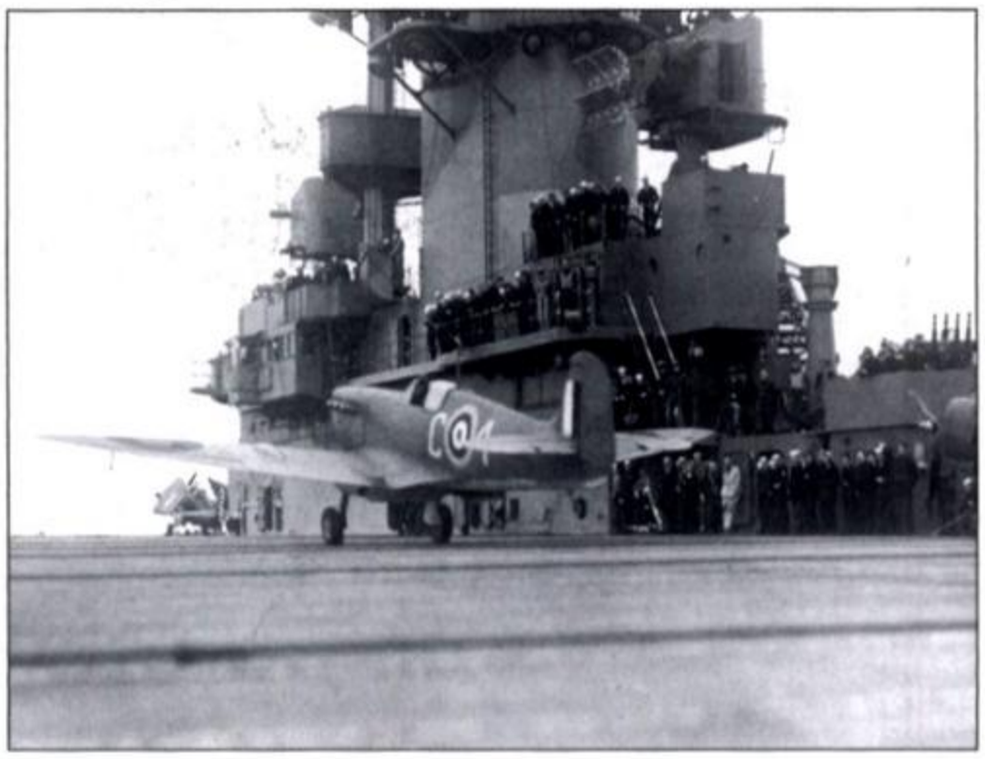
Above: Though this Mk VC, in the process of being craned aboard* Wasp*, appears to have 'clipped' wings, it is unlikely to have been flown from the carrier in this condition. Once aboard, it would have been reunited with its missing components before it was flown off when the carrier reached the Algerian coast.

Above: With HMS* Eagle *in the background, two deck crewmen on USS* Wasp *sit on the tailplane of a Spitfire Mk VC as its engine is run up. One of the ship's own aircraft, a Grumman Wildcat, can be seen in the foreground.



Spitfires were crammed into* Wasp*'s hangar deck en route to Malta. Operation Bowery was by no means the end of the reinforcement effort, as Royal Navy carriers* Argus, Furious *and* Eagle *continued to ferry aircraft to the beleaguered island until October. By the end of the month some 367 Spitfires had been delivered and issued to Nos 126, 185 and 249 Squadrons.

Above: His aircraft (with the name* Bob's the Boss *chalked on its engine cowling) held by deck crew, an RAF pilot does his pre-flight checks before departing for Malta.



Left: As* Wasp*'s crew look on, another Spitfire leaves the ship's decks for Malta. No sooner had the aircraft arrived than they were pitched into the battle against Luftwaffe Bf 109s. The first aircraft delivered were finished in Dark Earth/Middle Stone desert camouflage. Later shipments wore standard RAF temperate day fighter colours (Ocean Grey and Dark Green) as they spent much of their time on patrol over the Mediterranean rather than the desert.

continually adjusting their angle so that the engine ran at its most efficient speed of 3,000 rpm. At the very low temperatures the oil in the CSU was liable to congeal, causing the propeller blades to move into fully fine pitch. When that happened, engine rpm raced uncontrollably to around the 4,000 mark. With the Merlin threatening to shake itself to pieces, the pilot had to shut it down immediately. Then he had either to bail out or make a forced landing. Several Spitfires based in northern Australia were lost to CSU failures.

Australian attacks

Spitfires first engaged a major Japanese attack on 2 March 1943. Nine Mitsubishi G4M 'Betty' bombers attacked Coomali, escorted by 21 Mitsubishi A6M 'Zeke' fighters. Twenty-six Spitfires were scrambled to engage the raiders, but, due to problems with ground control, several fighters failed to intercept. Like those in the Battle of Britain, the actions fought over northern Australia were characterised by heavy overclaiming by both sides. The defenders claimed two A6Ms and a Nakajima B5N 'Kate' single-engined bomber destroyed, and a B5N damaged. Japanese records show that no B5Ns took part in the action; almost certainly those claimed hit were A6Ms. For their part, the

Right: Recently arrived Mk VBs are seen on a landing ground in Libya. AB326 was one of many Spitfires shipped to Takoradi on the Gold Coast, West Africa and to Casablanca, French Morocco for assembly and ferrying across the continent to their prospective squadrons.

Above: Army and RAF personnel hastily refuel and rearm a Mk VC on Malta during the defence of the island. Initially, a shortage of 20-mm cannon ammunition forced the removal of a pair of the four Hispanos fitted to these aircraft. This machine appears to have had its inner pair of cannon removed in this way.

Japanese claimed the destruction of three defending fighters, reported as 'P-39s and Buffalos'. In fact, neither side lost any aircraft in the encounter.

The next major Japanese incursion was on 15 March, when 19 G4Ms attacked Darwin escorted by 26 A6Ms fighters. Twenty-seven Spitfires took off to intercept and there was a fierce engagement around the bombers. The defenders claimed nine attackers destroyed, four probably destroyed and six damaged. In fact, no G4Ms were lost – though eight were damaged. One A6M fighter was lost. The raiders claimed the destruction of 11 defending fighters, and the probable destruction of five more; in truth, four Spitfires and two pilots were lost.

Above: While Malta was being reinforced, No. 145 Squadron became the first unit to fly the Spitfire in the Western Desert. The unit's aircraft were shipped from Britain to Takoradi, assembled and flown to Egypt. The first two aircraft arrived there in May 1942.

Below: No. 417 Squadron, RCAF formed in England in 1942 and was quickly posted to the Middle East. Flying with cockpit canopies open in the heat, a section of the unit's Mk VCs patrols over open desert.

Left: In a flooded dispersal, a Mk V of the 5th Fighter Squadron, 52nd Fighter Group, USAAF stands next to a stack of fuel tanks. Transferred from the 8th AF to the 12th AF in late 1942, the 52nd FG found tropicalised Mk Vs waiting for them in Gibraltar. Soon in action in Algeria, the 52nd finished the war in Italy.

Above: Spitfire Mk VCs of No. 2 Squadron, SAAF fly in line-astern over the Adriatic. Armed with four 20-mm Hispano cannon, No. 2's aircraft were based in Sicily and Italy during 1943. With minimal fighter opposition in Italy, Spitfire units spent much of their time on ground-attack duties, often carrying up to 500 lb (227 kg) of bombs. A less publicised role performed by Mk Vs in the Mediterranean was high-altitude interception. In 1942, the Aboukir MU modified two Mk VCs, removing much equipment and all armament. Two 0.5-in (12.7-mm) Browning guns, extended wingtips and a specially tuned Merlin 46 were installed. Two Luftwaffe Ju 86P reconnaissance aircraft were downed by these aircraft.

Above: Bomb-laden Spitfire Mk VCs of No. 2 Squadron, SAAF overfly the Sangro River in eastern Italy en route to a target during the Italian campaign.

Following another lull, the raiders returned on 2 May. This time the Japanese force comprised 18 G4Ms and 26 A6Ms. Thirty-three Spitfires scrambled to engage the attackers, but five suffered technical failures and had to return early. The action developed into a running battle around the bombers and continued some way out to sea. The defenders claimed seven enemy planes destroyed, four probably destroyed and seven damaged. In fact, all the raiders regained their base, though seven G4Ms and seven A6Ms had suffered damage. Five Spitfires were lost or probably lost due to enemy action.

For the defenders, worse followed when the Spitfires headed for home after breaking off the action. The Merlins had run for long periods at high throttle settings, leading to four cases of engine or CSU failures. A further five Spitfires ran out of fuel on the way home. Altogether, 14 Spitfires failed to regain their airfields after the engagement, and three pilots were posted missing. Of the aircraft that force-landed, one was later recovered intact, three were stripped for spare parts where they lay and the rest had to be written off.

There were further Japanese attacks on 9 and 28 May. During the latter action, Spitfires claimed three bombers shot down for the loss of two of their own. The actual

Above: Pilots from No. 601 'County of London' Squadron, RAuxAF were among those to fly Spitfires to Malta from USS Wasp in April 1942. This formation of No. 601 Squadron Mk VBs is led by Wg Cdr Ian Gleed in the aircraft, AB502, in which he was shot down and killed on 16 April 1943. Note his use of personalised codes, a privilege usually only accorded to RAF wing leaders.

Below: As the Allies occupied Sicily and moved north through the Italian mainland, they occupied and made use of captured Italian airfields. This Mk VC, fitted with twin cannon and four Brownings, wears the codes of No. 43 Squadron and shares the dispersal at Comiso, Sicily with Spitfires of later marks, probably Mk VIIIs.

Below: 'Yellow 14', a MG 151 20-mm cannon-armed Bf 109G-6/R6 Trop of JG 53, was abandoned at Comiso in late summer 1943. Spitfire Mk Vs struggled against these late model aircraft; the Mk VIII was more of a match.

Tactical reconnaissance

Spitfire LF.Mk VB
EP688 wears the colours of No. 40 Squadron, SAAF in late 1942. 'Clipped' wings, probably modified at No. 103 MU, and an 'Aboukir' filter are fitted. The red parts of the roundel and fin flash have been repainted orange, a feature of No. 40 Squadron's aircraft. Another feature peculiar to this unit was its code presentation: red with a white outline.

For fighter-reconnaissance duties No. 40 Squadron operated a number of suitably equipped LF.Mk VBs, sometimes referred to as 'FR.Mk VBs'. As well as 'clipped' wings the aircraft sported an oblique F.24 camera behind the cockpit on the port side of the aircraft and were specially prepared for the role. The latter involved taping over wing and skin joints and polishing the aircraft to help achieve the highest possible speed. So-equipped, these aircraft moved forward with the British 8th Army after the Battle of El Alamein in November 1942.

Left: A Spitfire Mk VC of No. 54 Squadron, RAF is pictured at Darwin, Northern Territory, Australia in March 1943. The fighter had not previously operated in a true tropical environment facing high humidity and extremely high temperatures on the ground, and very low air temperatures at altitude. They caused severe problems, the most serious of which was the repeated failure of constant-speed units (CSUs). These problems were cured in the Mk VIII, which replaced the Mk VCs. No. 54 Sqn was one of three RAF squadrons to join the RAAF units deployed to Australia for defence of that country. The others – Nos 548 and 549 – were formed in Australia in 1944 and flew Mk VIIIs exclusively. Both units disbanded in 1945.

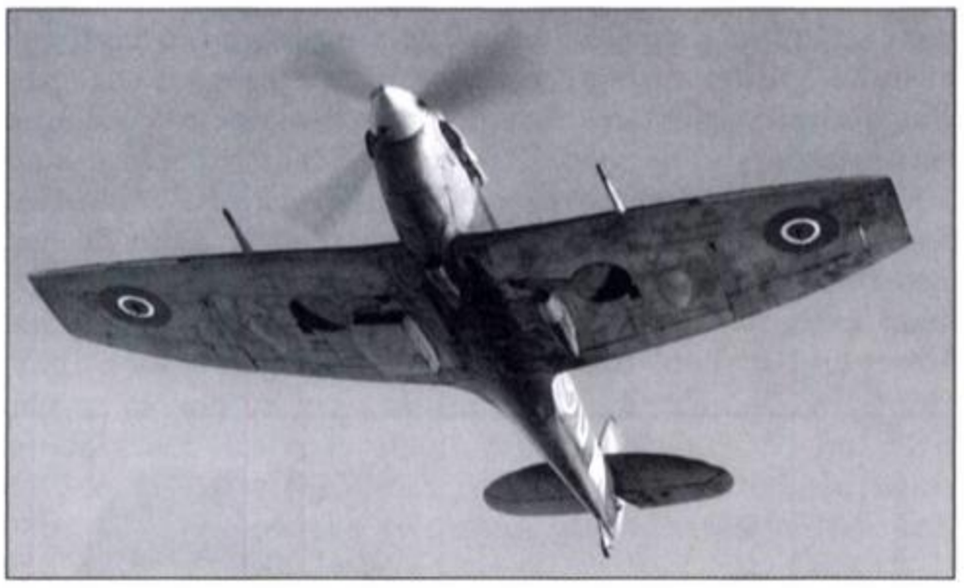
Japanese loss was two G4Ms shot down, and a third crash-landed near its base on Timor. Despite several claims, this was the first occasion on which a G4M had fallen to the Spitfires' guns.

Between then and the end of September, Japanese bombers carried out another five escorted attacks, incurring light losses during each. The lack of facilities at the airfields, and the general shortage of spare parts, reduced several Spitfires to a poor condition. Following action on 6 July, Squadron Leader Eric Gibbs, commander of No. 54 Squadron, had reported to his superiors: "Chiefly owing to the deplorable state of so many of our aircraft, for which no replacements have been forthcoming for months past, we were able to muster only seven Spitfires in the initial attack. Of the remaining four which were scrambled to intercept, one left the formation before the attack with a severe Glycol leak and subsequently force-landed, and three were unable to keep up. We lost two aircraft. Both pilots safe."

At the end of September the daylight raids ceased, giving way to occasional night attacks until they too ended after 12 November. Some published accounts have stated that the heavy losses the Spitfires inflicted had forced the raiders to cease their attacks; however, new research makes it clear that this was not the case. Throughout the series of attacks the Japanese losses had been remarkably light. The raids on Australia ended when they did because the experienced units were required elsewhere, after the war in the Pacific had taken a turn for the worse for the Japanese.

Above: Until their existence was made public, Spitfires supplied to Australia were referred to by the codename 'Capstan', after a brand of cigarette. The Spitfire's short range made the type unsuitable for patrolling the vast areas in the north of Australia.

'Clipped'-wing Mk Vs



Left: Most LF.Mk VBs, with their Merlin 45Ms that produced peak power at low level, were built with or later fitted with 'clipped' wings to improve their roll rate 'on the deck'. This view of AA937, with the Air Fighting Development Unit in 1943, illustrates the aircraft's plan view.

Above: Officially captioned as depicting the Spitfires that escorted General Montgomery's aircraft as it returned to England in May 1943, this photograph shows Mk VBs of No. 303 Squadron. Having been engaged in bomber escort duties and sweeps over occupied Europe since 1941, the unit received long-awaited Mk IXs the following month.

Left: This immaculate Mk VB, serialled BL479, served with No. 316 'City of Warsaw' Squadron for just two months before transfer to another Polish unit, No. 308 Squadron. Significant numbers of standard Mk VBs and VCs were equipped with 'clipped' wings, in both the European and Mediterranean theatres.

Above: With a fighter shortage at home and concern at USAAF HQ that aircraft like the Bell P-39 and Curtiss P-40 were inferior in performance to their expected German adversaries, Spitfires were requested to equip the fighter groups arriving in Britain in 1942, despite the fact that the RAF's Mk Vs were struggling against new Bf 109 and Fw 190 variants. This formation comprises Mk Vs of the 109th (coded 'VX') and the 12th ('RS') Reconnaissance Squadrons of the 67th Reconnaissance Group. As well as various support tasks, the 67th RG took part in fighter sweeps with RAF units.

Lima Challenger, *a presentation aircraft 'donated' by a resident of the Peruvian capital, was on strength with the 307th Fighter Squadron, 31st Fighter Group at Merston in August 1942. Eighth Air Force Spitfire Mk Vs were finished in RAF temperate colours. The aircraft's RAF serial number was applied in small figures on the tail.*

Spitfires for the USAAF

From mid-1942, 'reverse Lend-Lease' arrangements saw about 600 Spitfires made available to the USAAF, Mk Vs initially equipping the three squadrons of the 31st Fighter Group in June. With the similarly equipped 52nd FG, the 31st flew with the US 8th Air Force until October, when they were assigned to the 12th Air Force for Operation Torch, the Allied landings in North Africa. In September 1942, the three RAF 'Eagle' squadrons (equipped with Spitfires Mk Vs) were transferred to the 8th AF as the 4th FG. Also within the 8th Air Force, the 67th Observation (later Reconnaissance) Group (with four squadrons) employed Mk Vs for support duties and to fly fighter sweeps, while the 350th FG and the 496th Fighter Training Group had a limited number for training purposes. For Operation Torch, the 31st and 52nd FGs received tropicalised Mk Vs; once these units reached Italy in 1943, they received a few Mk VIIIs and IXs before transferring to the 15th Air Force and re-equipping with P-51 Mustangs. From November 1943, PR.Mk XIs equipped three of the four squadrons of the 7th Photographic Group.

For the reasons outlined above, the Spitfire Mk V failed to quell the attacks on Northern Australia. By the time the fighter's failings became known and had been reported to its makers, the series of raids had come to an end. The Mk V's successor in that theatre, the Mk VIII, incorporated modifications which overcame the problems encountered over Darwin.

Back in the summer of 1941, Rolls-Royce engineers had begun bench testing of a Merlin 45 engine fitted with two supercharger blowers in series, one feeding into the other. Between the outlet of the first blower and the inlet of the second was an intercooler, to reduce the temperature of the charge and so increase its density. The additional components added about 200 lb (90 kg) to the engine's weight and increased its length by 9 in (22 cm). Those differences were sufficiently small to allow the new engine to be fitted into the Spitfire airframe without major structural changes. The version of the new engine for use in fighters was designated the Merlin 61.

The engine company fitted an early Merlin 61 into the Spitfire III prototype, then serving as a testbed. Apart from a four-bladed propeller to absorb the extra engine power, the main external change was an enlarged radiator under the port wing to cool the liquid from the intercooler. The

'Mighty 8th' Spitfires

Spitfire Mk VB
USAAF Spitfires came from storage at RAF maintenance units and were finished in the RAF's Ocean Grey/Dark Green/Medium Sea Grey camouflage. US insignia were painted over the RAF roundels and the fin flashes were painted out. BM587 flew with the 309th FS, 31st FG in mid-1942.

Spitfire Mk VB
Equipped with Spitfires until late 1943, the 107th RS, 67th RG was based at Membury. BM181 exhibits the change in USAAF markings which occurred in June 1943, whereby a white bar was added to the cocarde, the entire marking being surrounded with a red border. Some units painted out the Sky Blue RAF fuselage band.

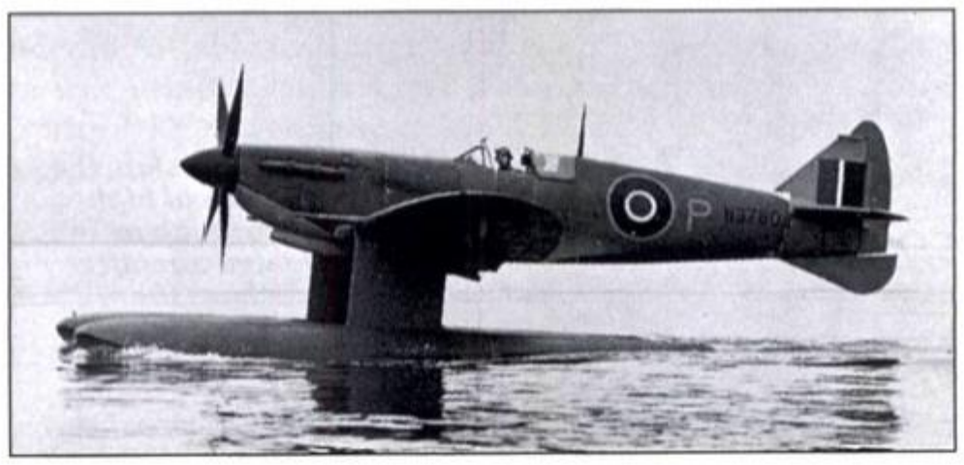
Fighting floatplanes

After Norway was attacked in April 1940, the RAF's campaign in defence of the country was hampered by the lack of suitable airstrips. Looking for solutions to the problem, the Air Ministry discussed the possibility of fitting floats to Hurricanes and Spitfires. To this end, a Spitfire Mk I (R6722) was fitted with a set of floats designed for the Blackburn Roc seaplane fighter and a scale model of a float-equipped Spitfire Mk III was tested. However, before the Mk I floatplane was completed, the Norwegian campaign ended. With the Battle of Britain looming, the urgent need for fighters saw R6722's conversion back to landplane standard. The floatplane fighter idea was dropped until 1942 when, after Japan entered the war, the idea was re-examined. This time three Mk Vs were fitted with floats designed by Supermarine and built by Folland. After trials the aircraft were declared combat-ready and shipped, not to the Pacific, but to Egypt in October 1943. From a concealed base on an unoccupied island in the Dodecanese group in the eastern Mediterranean, the Mk V floatplanes were to intercept German Ju 52 transports resupplying bases in the islands. However, after German troops and the Luftwaffe forced the British from the islands of Kos and Leros in October 1943, the plan had to be abandoned.

modified aircraft had an oblong-section radiator housing of similar external shape under each wing. The port housing contained the oil cooler radiator and part of the main coolant radiator; the starboard housing contained the other part of the main coolant radiator and the intercooler radiator.

The two-stage supercharger gave greatly increased engine power at high altitude. The Merlin 45 with the single-stage supercharger developed about 720 hp (537 kW) at 30,000 ft (9150 m). At that same altitude, the same basic engine with the two-stage supercharger developed about 1,020 hp (760 kW).

The Mk III with the experimental Merlin 61 installation began flight trials in the autumn of 1941, and initially there were problems getting the intercooler plumbing to work properly. By the end of 1941 the new engine was working satisfactorily, and revealed a huge improvement in the fighter's performance. Its maximum speeds were 391 mph (630 km/h) at 15,900 ft (4850 m), 414 mph (666 km/h) at 27,200 ft (8290 m) and 354 mph (570 km/h) at 40,000 ft (12200 m). The modified Spitfire's rate of climb far outstripped that of the Mk V, and its service ceiling was estimated to be 41,800 ft (12745 m).

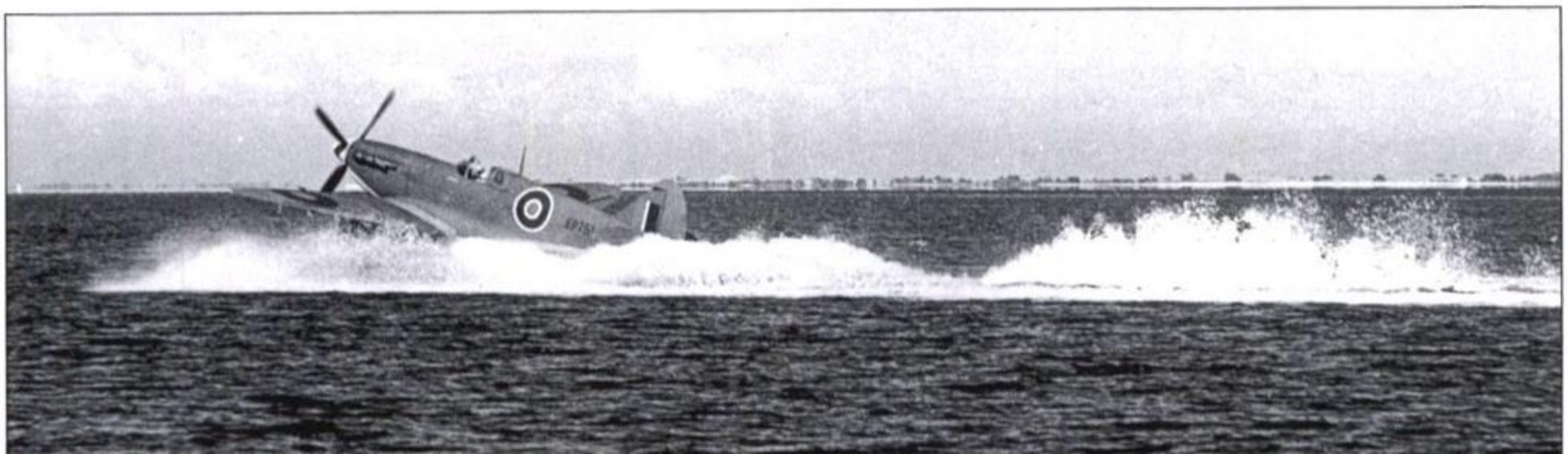


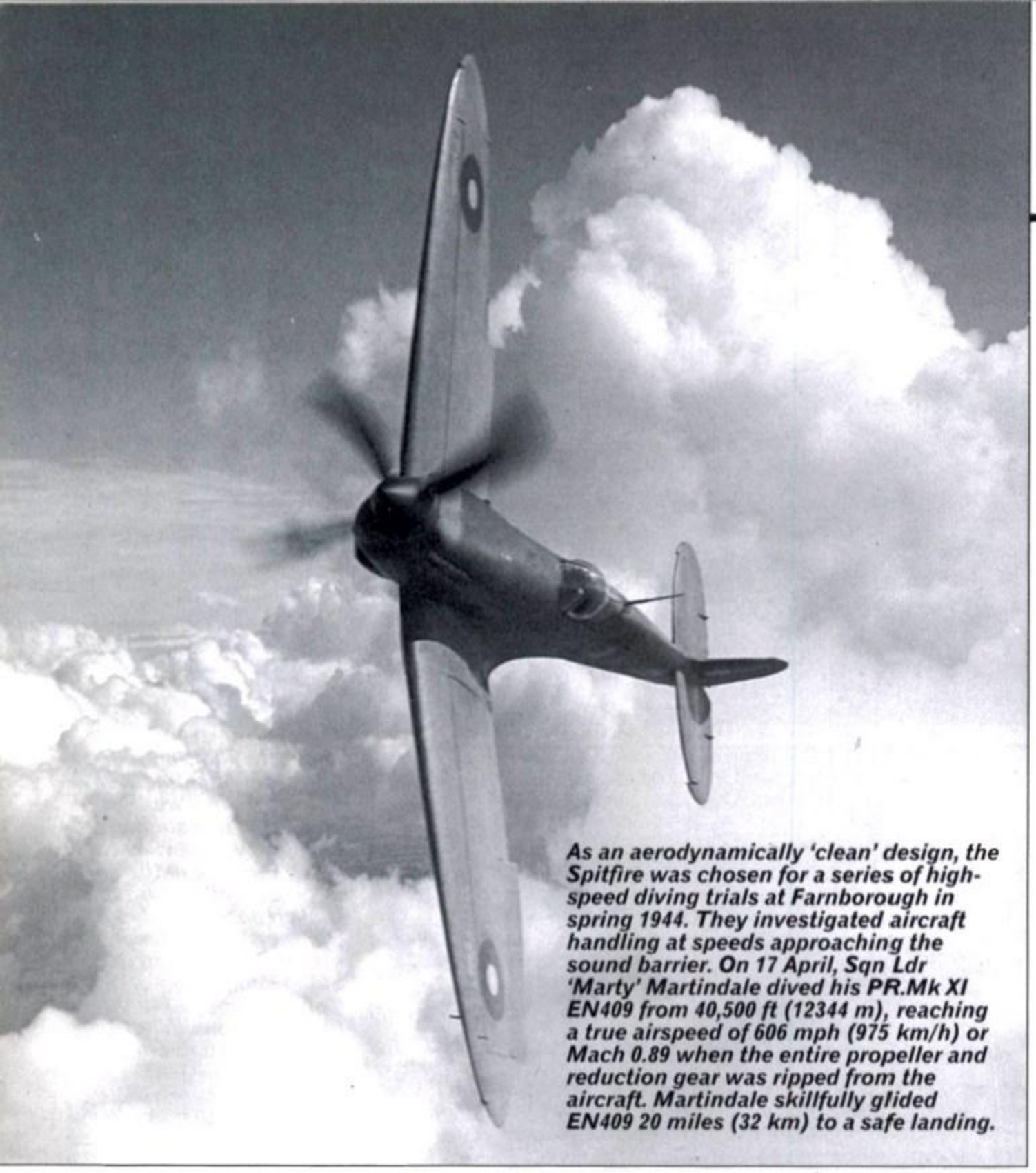
Above: The first Mk V conversion was W3760. As originally converted this aircraft had a Vokes tropical filter fitted, a normal shaped fin above the fuselage and no armament. In light of experience during early flights, a revised fin was fitted later, along with a Mk IX-type filter and cannon armament. Four-bladed propellers were fitted to all Mk V floatplanes.

Above: In addition to the three Mk V floatplanes, one LF.Mk IXB was converted to a similar standard with a view to using the type in the Pacific theatre. During trials it demonstrated a top speed only 30 mph (48 km/h) less than that of the landplane. Conversion of a Mk VIII had been considered initially. Pictured during trials in summer 1944, MJ892 was converted back to landplane standard when the idea was dropped.

Left and below left: After the Dodecanese operation was abandoned, the Spitfire Mk Vs were assembled and flown from Great Bitter Lake in Egypt. By November they were in Alexandria and had been returned to Britain by the summer of 1944. All were struck off charge in December.

Below left: Folland Aircraft converted the second and third Mk V floatplanes, EP751 and EP754. The best speed attained by these aircraft during trials was 324 mph (521 km/h) at 19,500 ft (5944 m), considerably less than that of the land-based variant. The floats' detrimental effect on the top speed of the floatplane fighter was always seen as a major drawback of the concept, especially if they were to encounter land-based opposition. It was this that ultimately brought an end to plans for Folland Aircraft to convert 12 more Mk Vs for use in the Pacific war.





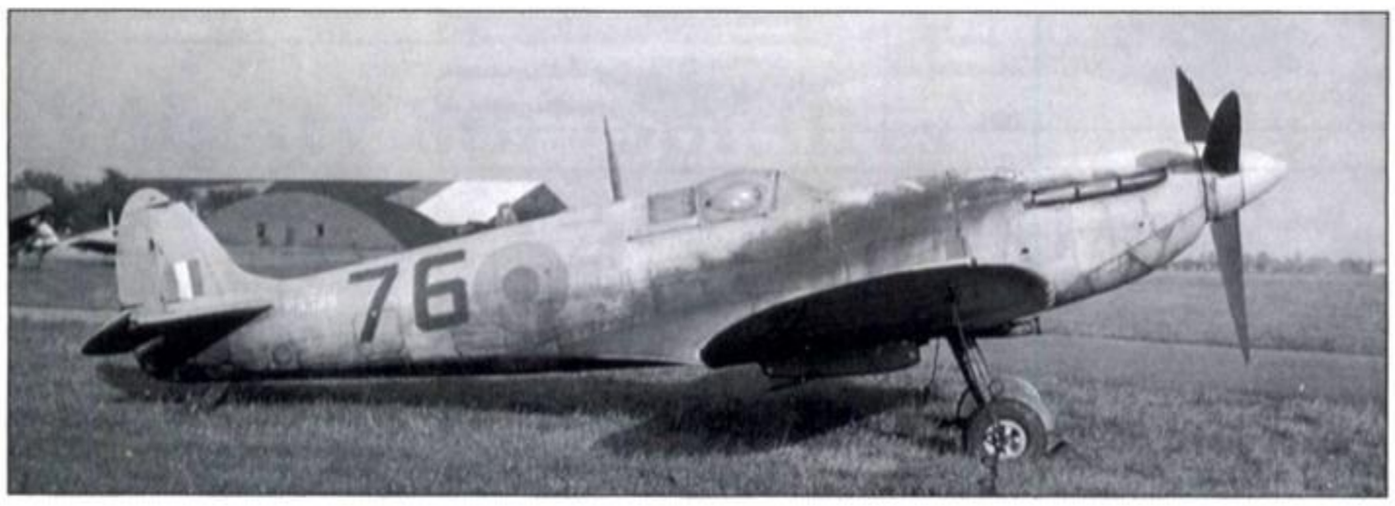
As an aerodynamically 'clean' design, the Spitfire was chosen for a series of high-speed diving trials at Farnborough in spring 1944. They investigated aircraft handling at speeds approaching the sound barrier. On 17 April, Sqn Ldr 'Marty' Martindale dived his PR.Mk XI EN409 from 40,500 ft (12344 m), reaching a true airspeed of 606 mph (975 km/h) or Mach 0.89 when the entire propeller and reduction gear was ripped from the aircraft. Martindale skillfully glided EN409 20 miles (32 km) to a safe landing.

Introduced as a counter to the mounting losses suffered by PR Spitfires at the hands of Fw 190s and new Bf 109 variants, the Spitfire PR.Mk Xs and Mk XIs (above) were virtually immune to fighter interception until the spring of 1944, when the first of the Luftwaffe's jet fighters entered service. Both were powered by Merlin 60 series engines.

Three new Spitfire versions

The successful combination of the Merlin 61 engine and the Spitfire airframe came at an opportune time. As mentioned above, the Spitfire V was no match for the Fw 190 fighter which entered service in the autumn of 1941. The new engine was rushed into production and formed the basis for three important new Spitfire variants: the Mk VII, the VIII and the Mk IX.

The Mk VII was a dedicated high-altitude interceptor variant, with a pressurised cabin like that fitted to the Mk VI, and the same extended-span wing. With the additional power at high altitude, it promised to be far more effective



'Camera Spits'

Suitably modified with camera equipment, extra fuel and, in some cases, cabin pressurisation, the Spitfire was the ideal high-speed 'PR' platform. Initial modifications were based on Mk Is, but the PR Spitfire evolved into a specialised sub-family, culminating in the PR.Mk XI in terms of Merlin-powered aircraft. Operating at extreme range, PR Spitfires undertook both low- and high-altitude work in extremely dangerous circumstances.

An oblique camera port behind the cockpit indicates the low-level 'dicing' role for which the PR.Mk VII (originally the PR Type 'G', then PR.Mk IG) was intended. Some were camouflaged, though most were finished in very pale pink.

Above: For low-level armed reconnaissance work, the PR.Mk XIII was introduced in early 1943. Converted from Mk I or V fighters or PR.Mk VIIs, the 26 Mk XIIIs featured a 'low-level' Merlin 32 and four 0.303-in (7.7-mm) machine-guns in the outer wings for self-defence.

Below: The intake below the exhaust ports on the starboard side of this aircraft indicates that cabin pressurisation was fitted to this aircraft, a PR.Mk X. Effectively a high-altitude, pressurised version of the PR.Mk XI, the Mk X entered service after the latter type and was not as popular with pilots, as visibility from its heavy Perspex canopy was poor. Only 16 were built, entering service with Nos 541 and 542 Squadrons from May 1944.

Left: This work-stained, Rotol propeller-fitted aircraft, ordered as a Mk I fighter, served as a PR.Mk III and later as a PR.Mk VI. The former was the first long-range PR variant, with extra fuel in the fuselage and in a small blister tank under the port wing. This was counterbalanced by two small cameras in a blister on the opposite wing.

In 'PR blue'

Spitfire PR Type 'F' (PR.Mk VI)
Ordered as a Spitfire Mk I, X4498 was converted to PR Type 'C' (Mk III) standard shortly after completion and in 1942 had a Merlin 45 fitted to become a Type 'F'. It is finished in the colours of No. 3 Photo Reconnaissance Unit at RAF Oakington, July 1941.

Unsuccessful Mk VI

Left: Answering a perceived threat from high-altitude bombing by the Luftwaffe, the Mk VI was developed from the Mk V with a pressurised cabin, extended wingtips and a high-altitude Merlin 47 driving a four-bladed propeller. However, once in service it was unable to fight above 35,000 ft (10668 m). Mk VII BR579 was a No. 124 Squadron aircraft.

Above: Only two squadrons were fully equipped with Mk VIs and their successes were few. A number of other units used the type during brief stints based in the Orkneys and Shetlands while being rested. Six aircraft were also shipped to Egypt to join Mk VCs specially modified for high-altitude interception, but they failed to match the latter's performance.

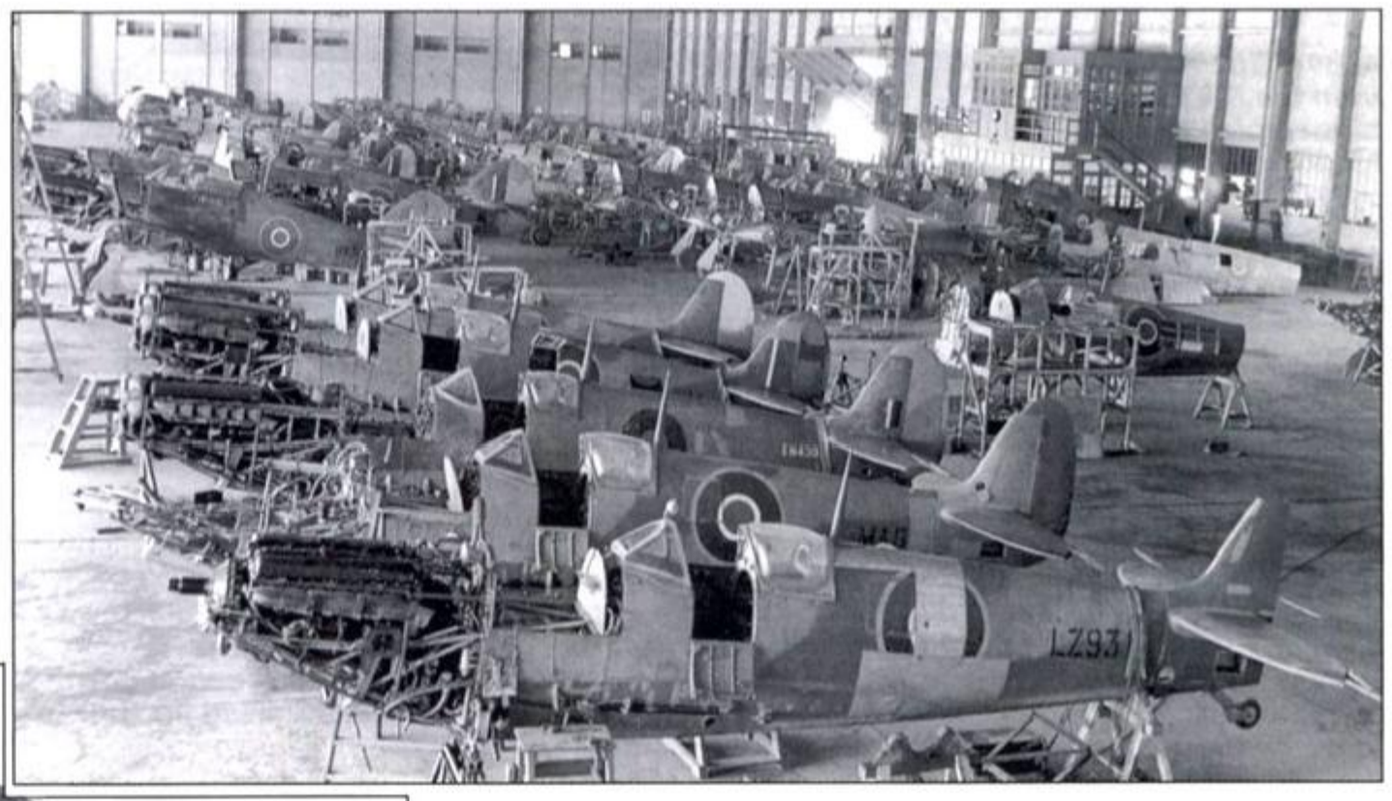
than its predecessor. To permit a high-speed climb to altitude, perhaps followed by a long tail chase, the Mk VII had increased fuel tankage. Two extra fuel tanks were built into the wings, increasing the total internal fuel capacity to 124 Imp gal (563 litres). The airframe was redesigned and strengthened to cope with the extra weight and, to reduce drag, the tail wheel was made to retract. The second of the new variants, the Mk VIII, was a general-purpose fighter incorporating most features of the Mk VII except for the pressurised cabin.

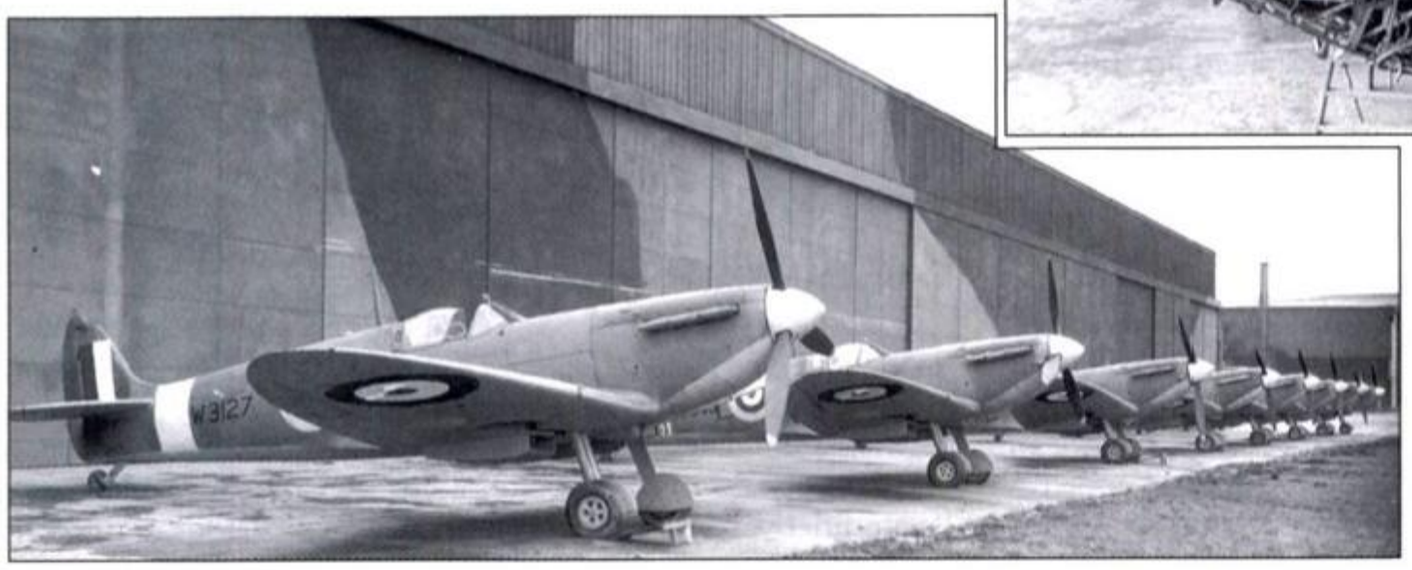
The redesign work on the airframes of the two variants, and the retooling of production lines to build them, took several months. As a result, neither the Mk VII nor the Mk VIII became available in quantity until the middle of 1943.

With its Spitfire V units hard-pressed by Fw 190s whenever they ventured over northwest Europe, Fighter Command could not afford to wait that long. Its urgent need was for an interim Spitfire variant powered by the Merlin 61, able to engage the Fw 190 on equal terms. And it was wanted quickly. The stopgap variant became the Spitfire IX, essentially a Mk VC with the minimum of modification necessary for it to take the new engine. There was no attempt to restress the airframe of the Mk IX to

Repair and salvage

Below: Newly overhauled Spitfire Mk Vs at Westland's Ilchester plant await delivery to squadrons. W3127, nearest the camera, was built in 1941 and visited Westland twice for repair and/or modification during its career, finishing up at the Central Gunnery School before being reduced to instructional airframe status in 1946.

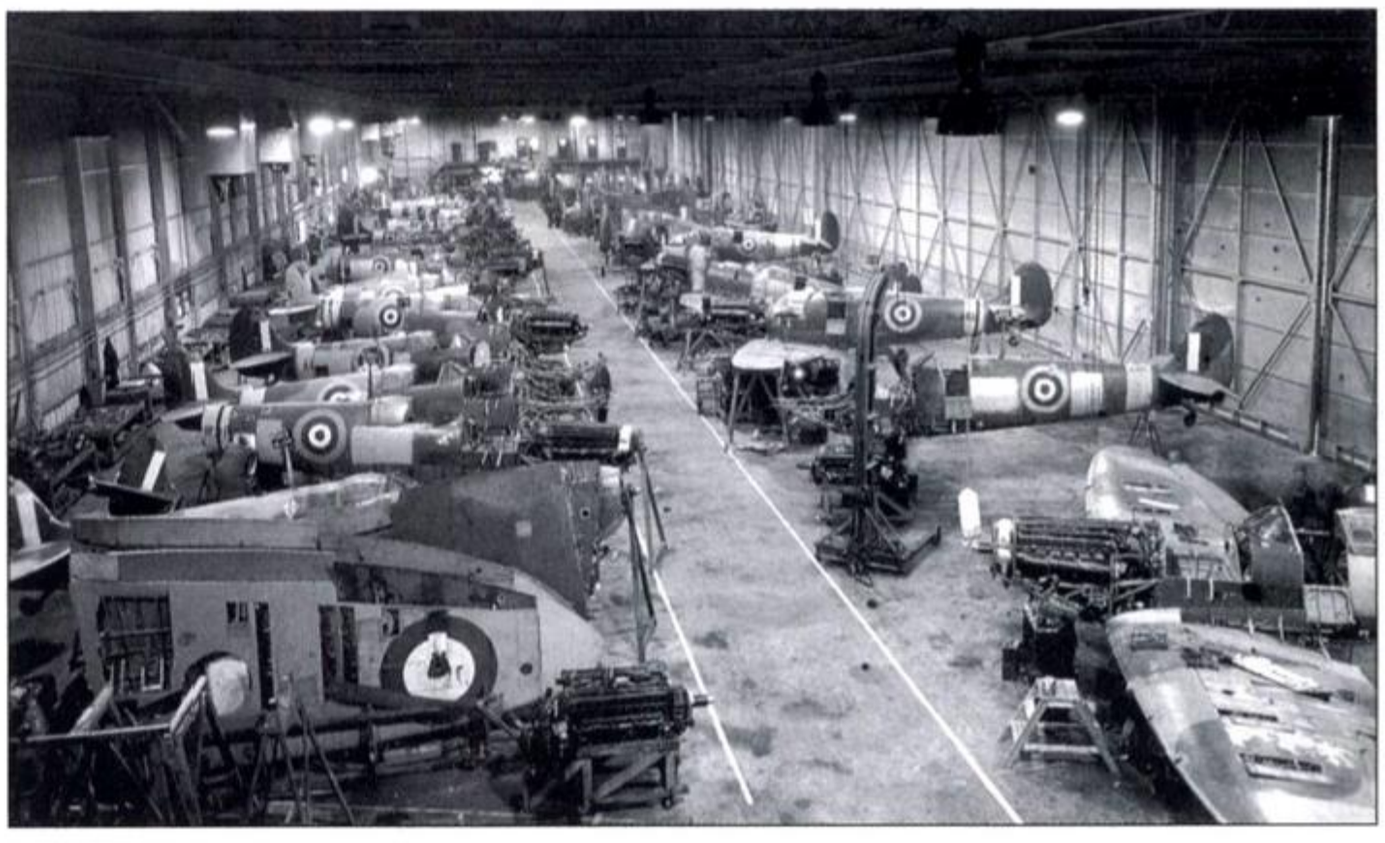




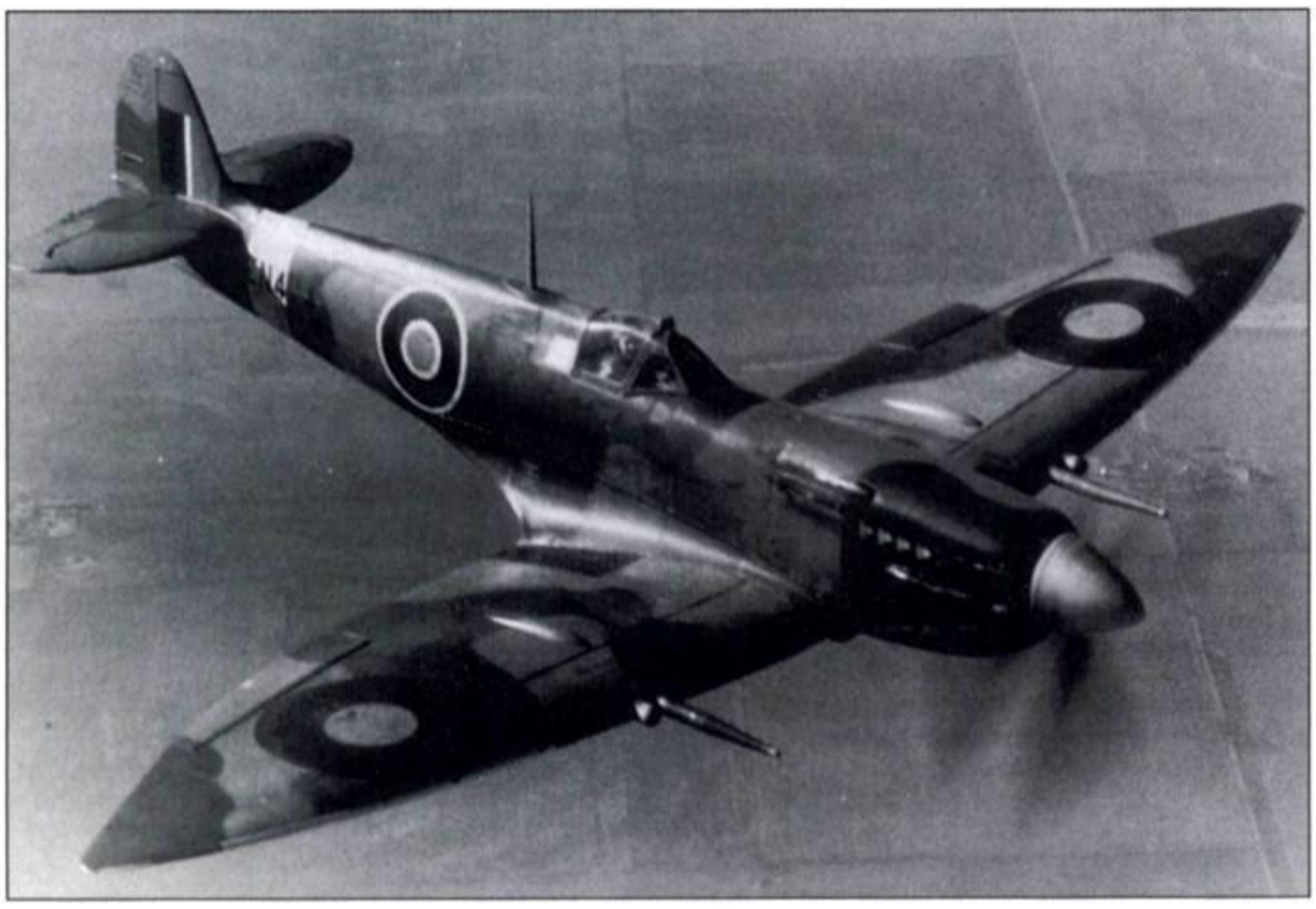
Above: Spitfire Mk Vs (including a USAAF example) and at least one PR.Mk XI share a large hangar with Hawker Hurricane Mk IIs at a maintenance unit (MU) 'somewhere in North Africa', possibly Aboukir, Egypt. No. 103 MU at Aboukir was responsible for reconditioning as many as 140 Allied aircraft per month during the height of the desert war.

Below: Inside Westland's Ilchester plant, at least 20 Spitfires (mainly Mk Vs), their old unit codes painted out, undergo refurbishment. This major undertaking was tackled by several companies.

Below: In every theatre, RAF repair and salvage units performed vital work behind the lines, recovering damaged airframes for potential repair and return to service. Here a Bedford/'Queen Mary' combination rescues an unserviceable Spitfire Mk V near the Tunisian front, probably in 1942.

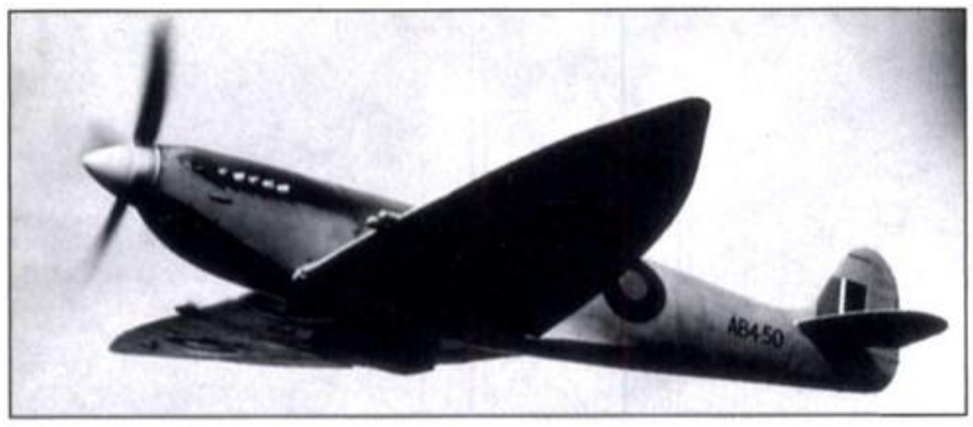


High-flying Mk VIIs



Above: A Spitfire Mk VII of No. 131 Squadron is pictured in the spring of 1944 when the unit was based at Culmhead. The upper surfaces were painted in the light grey high-altitude camouflage, with toned-down national markings on the fuselage, tail and top surface of the wings. There were no markings under the wings.

Above: Distinguished from the Mk VI by its retractable tailwheel, the Mk VII was a much improved aircraft. As well as a more powerful Merlin 60 series engine, the Mk VII had more fuel capacity, improved cabin pressurisation and 'C' wing armament. EN474, seen here flying in the US, was one of 140 Mk VIIs built by Supermarine and was shipped across the Atlantic in April 1943. Coded as (foreign evaluation airframe) 'FE-400', it was assessed by the USAAF. It survived the war, to be displayed at the National Air & Space Museum, Washington, DC.



AB450 was built in August 1942 as a Mk VB and was immediately converted to become the Mk VII prototype. In September it was issued to the High Altitude Flight at Northolt, set up to combat high-flying Junkers Ju 86P bombers, and was absorbed in early 1943 by No. 124 Squadron. Here it was painted PR Blue with Medium Sea Grey undersides. Apparently fitted with a 'C' wing, its guns had been removed at this point.

compensate for the increase in all-up weight. Pilots were warned of the dangers of overstressing the new variant in combat.

The Mk IX in service

In July 1942, No. 64 Squadron at Hornchurch became the first unit operational with the Spitfire IX. On 30 July, Flight Lieutenant Donald Kingaby gained the first victory in the new variant. Afterwards, he reported: "I sighted approximately 12 Fw 190s 2,000 ft below us at 12,000 ft just off Boulogne, proceeding towards French coast. We dived down on them and I attacked an Fw 190 from astern and below, giving a very short burst from 300 yd. I was forced to break away as I was crowded out by other Spits. I broke down and right and caught another Fw as he commenced to dive away. At 14,000 ft approx I gave a burst of cannon and M/G, 400 yd range hitting E/A along fuselage. Pieces fell off and E/A continued in straight dive nearly vertical. I followed E/A down to 5,000 ft over Boulogne and saw him hit the deck just outside the town of Boulogne and explode and burn up. Returned to base at 0 ft."

Although Kingaby's victory attracted little attention at the time, it marked a significant turning point for Fighter Command. It was the first occasion when the Spitfire had engaged the feared Fw 190 on equal terms. For the Luftwaffe, that engagement marked the beginning of the end of the air superiority it had established over northwest Europe nearly a year earlier.

Spitfires had their hardest day's fight, ever, on 19 August 1942. On that day British and Canadian troops carried out amphibious landings at and beside the port of Dieppe in northern France. Forty-eight squadrons of Spitfires supported the landings, 42 with Mk Vs, two with Mk VIs and four with the new Mk IXs. These units flew 171 squadron-sized patrols totalling 2,050 sorties (out of a grand total of 2,600 sorties flown by all Allied aircraft involved in the operation). Also during that action, the Spitfire squadrons suffered their heaviest single day's loss ever: 59 aircraft lost to enemy action out of a total Allied loss of 97.

In the months that followed, many more home-based units re-equipped with the Mk IX, and it became the most-used fighter type in the theatre.

Combat in the stratosphere

A few days after the Dieppe action, the Luftwaffe opened a new phase in its air attack on England. The so-called Hohenkampfkommando (High Altitude Bomber – Detachment), with a strength of two Junkers Ju 86R bombers, began operations from Beauvais in northern France. Powered by two turbo-supercharged diesel engines with

This Spitfire Mk VII of No. 131 Squadron was pictured in June 1944. By then the aircraft had been repainted in normal day fighter camouflage and carried invasion stripes. The pointed tip of the extended-span wing is evident, as is the additional air scoop on the starboard side of the engine that provided air for the cabin pressurisation blower.

Propeller
To absorb the extra power of the Merlin 60 series engines, a four-bladed Rotol Jablo propeller was introduced on the Mk VII/VIII/IX aircraft.

Performance
With a Merlin 71 installed, the Mk VII was capable of 424 mph (682 km/h) at 29,500 ft (8994 m) and had a range of 660 miles (1063 km) without reserves.

Armament
By the time the Spitfires of the Mk VII/VIII/IX series were in production, the 'C' or 'Universal' wing had become standard (though late-production Mk IXs carried the 'E' wing). Despite the versatility of the 'C' wing, two 20-mm Hispano cannon and four 0.303-in (7.7-mm) Browning machine-guns was by far the most commonly fitted armament combination. Aircraft assigned to ultra-high-altitude operations sometimes flew with just four machine-guns to save weight.

Engine
Most Mk VIIs were fitted with Merlin 64s with a Marshall Mk XII blower (with an inlet on the starboard side of the engine cowling) to provide cabin pressurisation. A small number were fitted with 'high-altitude' Merlin 71s; some sources refer to these aircraft as 'HF.Mk VIIs'.

Fuel capacity
Mk VIIs had increased capacity in their forward fuselage tanks (97 Imp gal/441 litres), and leading-edge tanks in the wings provided another 28 Imp gal (127 litres). Often a jettisonable belly tank was also carried; this aircraft carries a 45-Imp gal (205-litre) tank.

Control surfaces
Wingtip extensions added 3 ft 4 in (1.02 m) to the span of the Spitfire Mk VII compared to the Mk V. The type's ailerons were of reduced span, its elevators had extended horn balances and, on later aircraft (like this one) a broader chord rudder was introduced. This latter feature became standard on late production Mk VIIIs, IXs and XVIs.

Spitfire F.Mk VII Culmhead Wing June 1944

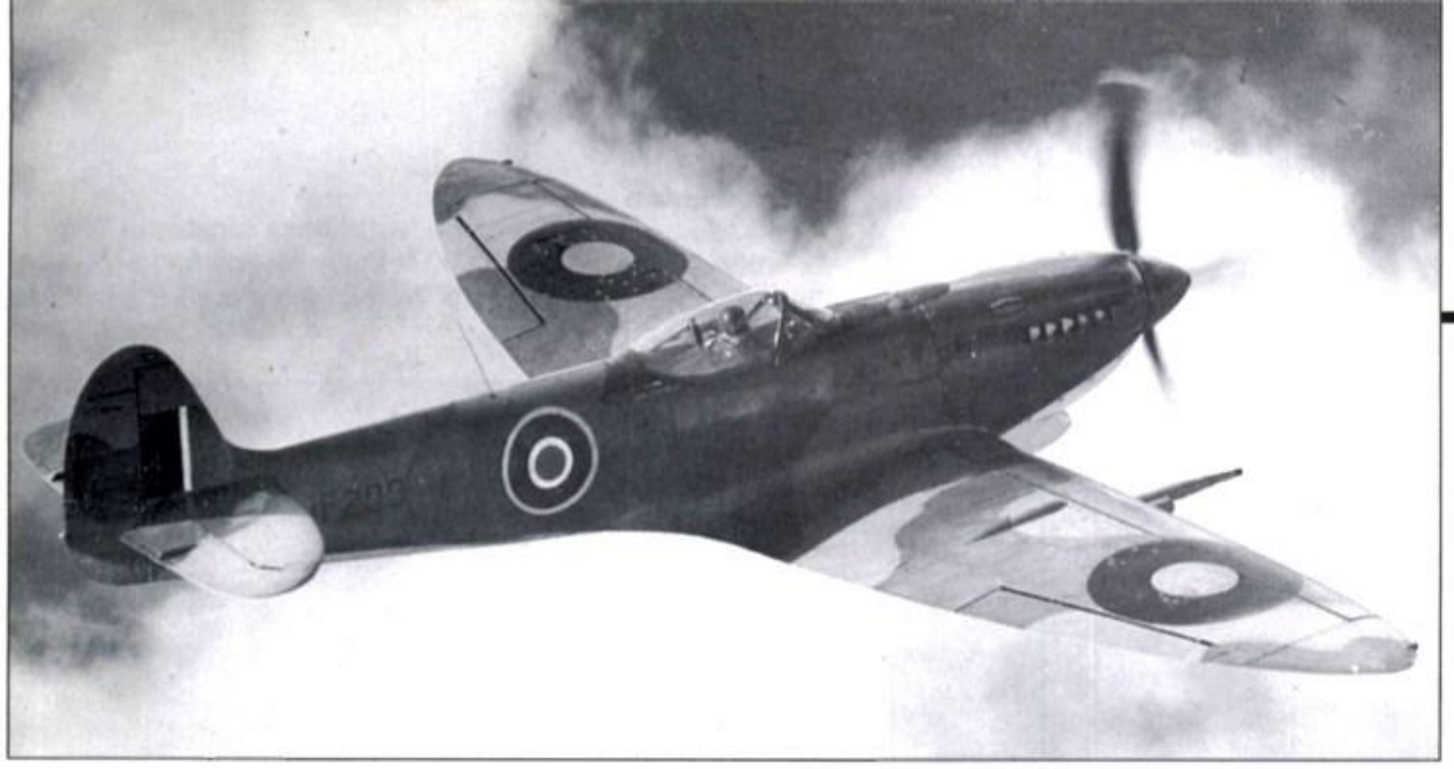
MD188 was one of the last Mk VIIs built, first flying on 21 May 1944. Issued to No. 131 Sqn the following month, the aircraft was soon with the Culmhead Station Flight as the personal mount of Wg Cdr Peter Brothers.

Cabin pressurisation
A much improved cabin sealing system was introduced in the Mk VII which allowed a return to a sliding cockpit canopy. The system fitted to the Mk VI would not allow the fitment of the standard sliding hood, though it was jettisonable.

Markings
Standard RAF high-altitude colours, as applied to MD188, consisted of PR Blue upper surfaces and Deep Sky, Type S undersurfaces. Illustrated as it appeared in June 1944, just prior to Operation Overlord, it has black and white 'invasion' recognition stripes applied to the rear fuselage and the upper and lower wing surfaces. High-altitude types generally carried two-colour roundels (Type B) and fin flashes.

Personal codes
Having command of a wing allowed an RAF officer to apply his initials to the fuselage and nose of his aircraft, in place of the more usual unit codes.

Wing Commander Peter Brothers
On 7 August 1944, Peter Brothers scored the last of his 16 'kills' of the war (and his only one in a Mk VII) in this aircraft, shooting down an Fw 190 over France. The rest of his victories were made on Hurricane Mk Is and Spitfire Mk VBs.



Significant as the first Spitfire fitted with a bubble canopy, Mk VIII JF299 flew in this form in mid-1943. Flown by experienced pilots at the Air Fighting Development Unit, Duxford, the modified aircraft was very well received. As it did not adversely effect the aircraft's performance the 'rear-view fuselage' was applied to late wartime production Mk VIIIs, IXs and XVIs, as well as Griffon-engined Mk XIVs.

nitrous oxide injection, the new German bomber delivered attacks from altitudes above 40,000 ft (12200 m). Its puny load was a single 550 lb (250 kg) bomb, its maximum speed was little over 200 mph (320 km/h) and it lacked defensive armament. However, there were good grounds for believing that the bomber's excellent altitude performance would keep it beyond the reach of the defences. Obviously, the raids could not inflict much in the way of damage, but with Germany's own cities coming under increasingly heavy attack, the high-flying bombers would score useful propaganda points by delivering daylight attacks against which the British defences were shown to be impotent.

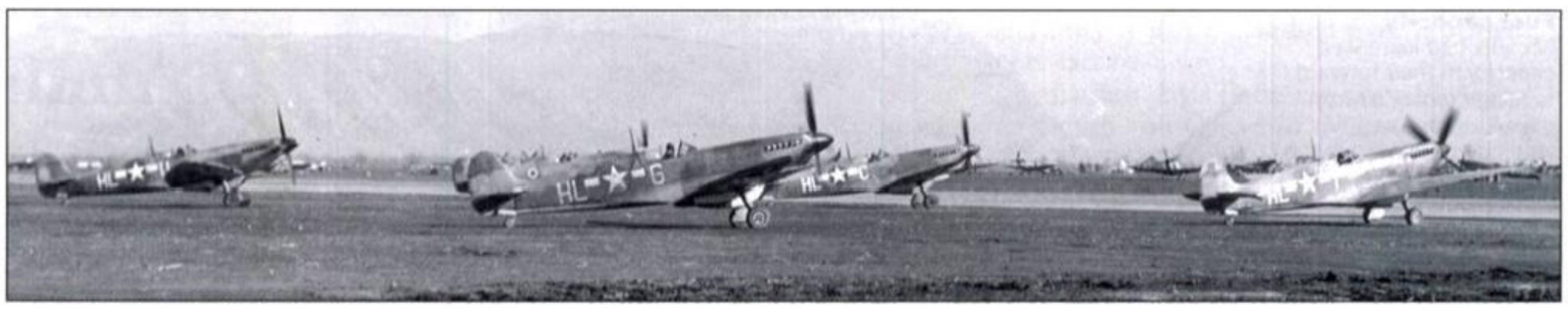
The first Ju 86R raid attack took place on 24 August 1942, when one aircraft bombed Camberley and the other bombed Southampton. Fifteen Spitfire Vs were scrambled but none reached a firing position. During the next two and a half weeks, the Ju 86Rs flew another 10 sorties over England, all without encountering effective fighter interference.

Merlin 61 power

Below: JF463 arrived in North Africa in June 1943, though no record of the unit to which it was initially issued has survived. As all Mk VIIIs were intended for overseas service, all were built with a Vokes Aero-Vee tropical filter fitted. The 'C' wing was also standard on the Mk VIII.

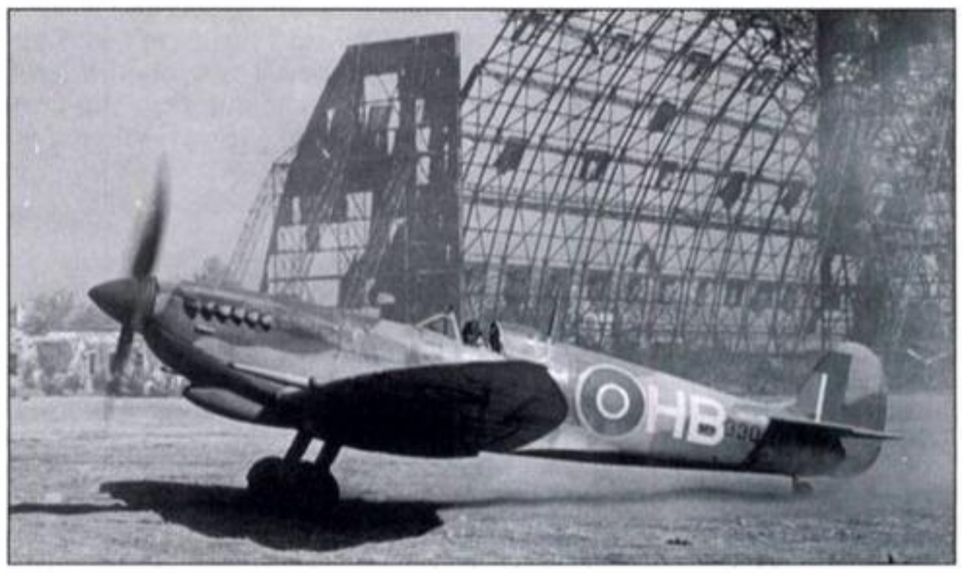
The high-flying bombers' spell of invulnerability was fast drawing to a close, however. Fighter Command formed a new fighter unit, the Special Service Flight based at Northolt, to counter the menace. Two Spitfire IXs were expressly prepared for high-altitude operations. They were fitted with specially tuned Merlin 61 engines with a slightly higher reduction gear, and lightened by the removal of armour, the four machine-guns and all other unnecessary items of equipment.

Right: Spitfire Mk VIIIs of the 308th Fighter Squadron, 31st Fighter Group, 12th Air Force are seen at Castel Volturno, Italy, early in 1944. Fifty-five Mk VIIIs operated alongside Mk Vs with the 308th; other squadrons of the 31st FG flew Mk Vs and IXs.



Right: No. 145 Squadron, the first unit to be equipped with Mk Vs in North Africa, became the first Mk VIII unit in June 1943, based at Malta. Seen at Fano, Italy in November 1944, this aircraft carries No. 145's 'trademark' white-outlined codes, has had its fuselage band (and part of its serial number) painted out and carries a 500-lb (227-kg) bomb.

Below: AVM Harry Broadhurst, AOC Desert Air Force (the youngest AVM in the RAF at 38 years old) taxis his personally coded Mk VIII past the remains of airship hangars at Taranto, Italy in the summer of 1943. Having become privy to the 'Ultra' secret, the Allies' successful breaking of the German 'Enigma' code, Broadhurst was, by this stage, forbidden from flying on operations. His aircraft has extended wingtips, of the type applied to Mk VIIs and fitted to early production Mk VIII aircraft. Four Merlin variants were fitted to Mk VIIIs. Standard F.Mk VIIIs had either a Merlin 61 or 63. From late 1942, role prefixes were officially applied, but not always used – 'LF' for aircraft with the 'low-level' Merlin 66 fitted; 'HF' for Merlin 70-fitted, high-altitude examples.



Left: The entire production run of Mk VIIIs was delivered to units based overseas. This example belonging to No. 417 Squadron, RCAF is pictured at Venafro in Italy in the summer of 1944. Earlier this aircraft had served with the US 31st Fighter Group, and when the latter converted to P-51s it was returned to the RAF.

Replacing SEAC Mk Vs

Below: Spitfires were first deployed to the Far East in late 1943, when Mk VCs replaced Hawker Hurricanes in Nos 136, 607 and 615 Squadrons, RAF on the Burma front. They were ultimately replaced by Mk VIIIs. The Indian Air Force also flew Mk Vs and VIIIs in the India-Burma theatre. Few photographs of the IAF's Mk VIIIs exist; here, personnel service a No. 8 Squadron aircraft in Burma, 1945.

Above: RAF personnel of No. 81 Squadron show their extended wingtips-fitted Mk VIIIs to local people at Imphal. No. 81 was one of the first two units equipped with the Mk VIII in the Far East in late 1943. Finished in the Dark Green/Dark Earth camouflage applied to South East Asia Command (SEAC), with Blue/Sky Blue roundels, these aircraft lack the broad white recognition stripes applied later to SEAC aircraft. Red was removed from the markings carried by Allied aircraft in the Far East to avoid confusion with Japanese aircraft.

Left: No. 607 'County of Durham' Squadron Mk VIIIs rest at Imphal as a USAAF B-25 prepares to take off in the background. Though encounters with the enemy were initially rare, by mid-1944 these aircraft were engaged in the fight for air supremacy with the Japanese army. From early 1945 the unit turned to the fighter-bomber role, supporting Allied armies in Burma.

On 12 September a Ju 86R headed across the English Channel for yet another attack, but this time the defenders were ready. Pilot Officer Emanuel Galitzine took off from Northolt in one of the specially modified Mk IXs. He climbed to 40,000 ft (12200 m), heading southwest under radar control. As he neared the Isle of Wight he caught sight of the German bomber, slightly higher and to starboard. At about the same time that the crew of the Junkers saw him, the pilot jettisoned the bomb and selected full power in an attempt to outclimb the interceptor. The much-lightened Spitfire climbed more quickly, however, and Galitzine moved into an attacking position above and behind his quarry. "I positioned myself for an attack and dived to about 200 yd astern of him, where I opened up with a three-second burst. At the end of the burst my port cannon jammed and the Spitfire slewed round to starboard; then, as I passed through the bomber's slipstream, my canopy misted over."

It took about a minute for the Spitfire's canopy to clear, then Galitzine closed in for another attack on the Ju 86R which was now heading south and trying to escape out to sea. By clever manoeuvring, the bomber crew avoided that attack and the two that followed. At one stage in the action the pair exceeded 43,500 ft (13260 m), but then the Junkers entered a patch of mist and Galitzine lost contact. Running short of fuel, he broke off the action.

SEAC ace at Imphal

Spitfire LF.Mk VIII
In this aircraft Australian Flt Lt Wilfred Goold shot down a Nakajima Ki-43 'Oscar' and damaged two others over Palel on 18 May 1944. 'AF' was the code of No. 607 Sqn, RAF then based at Imphal. Goold shot down five Japanese aircraft in total. All were 'Oscars' claimed while in India with No. 607 Sqn.

Above: Mk VIIIs of No. 452 Squadron, RAAF are seen at Sepinang airstrip, Borneo in early August 1945. 'Ace of Spades' markings on the tails of these aircraft indicate its inclusion in No. 80 Wing, RAAF.

The Ju 86R landed at Caen bearing scars from the action: a single hole above and below the port wing, where a 20-mm armour-piercing round had passed clean through the structure. Obviously, the new bomber was not immune from fighter attack at high altitude, and the operations by the Hohenkampfkommando came to an abrupt halt. The action on 12 September 1942 was the highest-altitude combat fought during World War II.

Spitfire Mk IXs in North Africa

Towards the end of 1942, the Luftwaffe moved a Gruppe of Fw 190s to Tunisia. Initially confronting Spitfire Vs and fighters of lower performance, the German unit was for a time able to secure temporary air superiority over selected parts of the battle area. Then, as over northwest Europe, the RAF countered by moving Spitfire IX units into the area. No. 81 Squadron went into action with them in January 1943, followed soon afterwards by No. 72 Squadron. Another important addition was the Polish Fighting Team, a 16-pilot volunteer unit equipped with Mk IXs. Led by Squadron Leader Stanislaw Skalski, it included several other aces including Karol Pniak, Waclaw Krol, Eugeniusz Horbaczewski and Kazimierz Sporney. At the same time, the US 31st and 52nd Fighter Groups also received some Mk IXs and flew them alongside their Spitfire Vs.

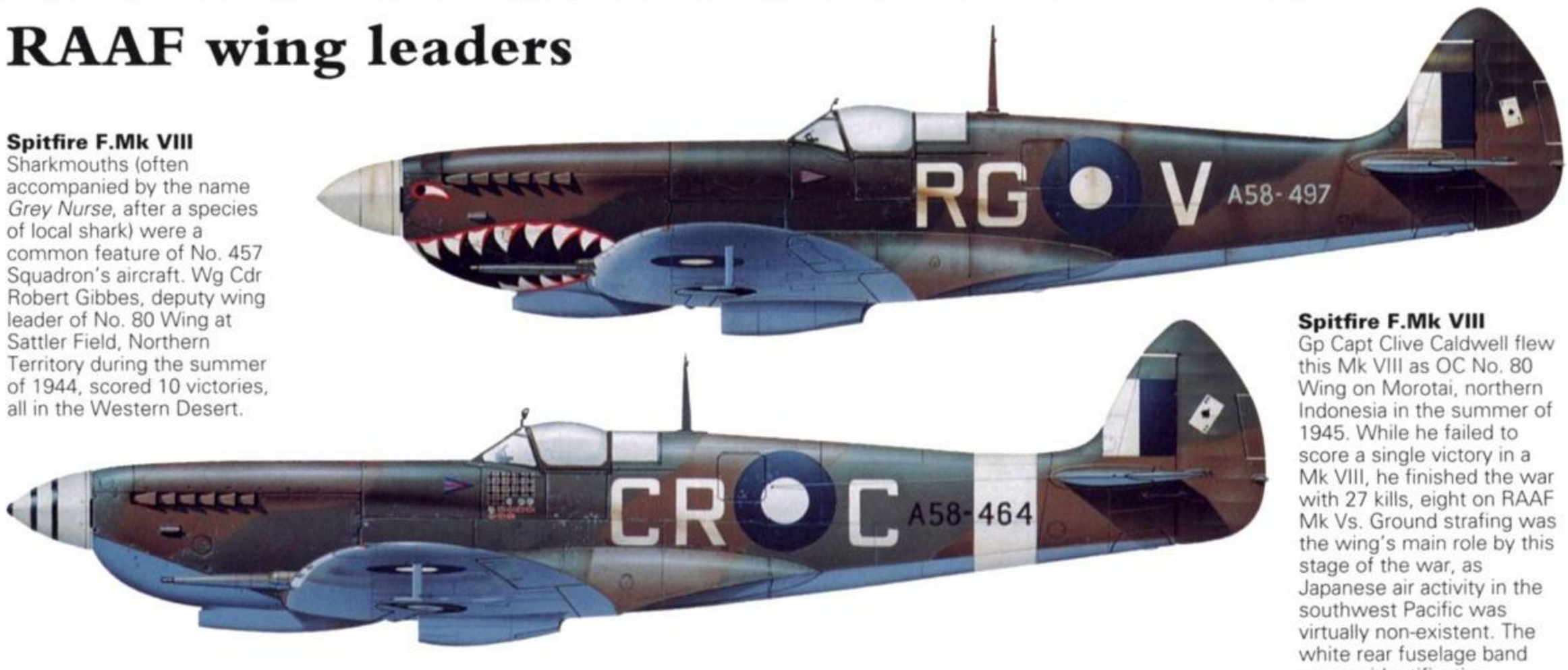
The Mk IXs quickly restored air superiority, and assisted in the tightening of the air and sea blockade of Axis supply

Australian Eights

Above: This formation of Spitfire VIIIs of No. 548 Squadron operated from Darwin, northern Australia, early in 1945.

Right: With grey exhaust stains caused by a lean running engine, a Mk VIII of No. 79 Squadron, RAAF is pictured at Biak, New Guinea, in April 1945. From September 1944 HF.Mk VIIIs began to arrive in Australia; they carried serial numbers in the A58-6xx series.

RAAF wing leaders



Spitfire F.Mk VIII
Sharkmouths (often accompanied by the name *Grey Nurse*, after a species of local shark) were a common feature of No. 457 Squadron's aircraft. Wg Cdr Robert Gibbes, deputy wing leader of No. 80 Wing at Sattler Field, Northern Territory during the summer of 1944, scored 10 victories, all in the Western Desert.

Spitfire F.Mk VIII
Gp Capt Clive Caldwell flew this Mk VIII as OC No. 80 Wing on Morotai, northern Indonesia in the summer of 1945. While he failed to score a single victory in a Mk VIII, he finished the war with 27 kills, eight on RAAF Mk Vs. Ground strafing was the wing's main role by this stage of the war, as Japanese air activity in the southwest Pacific was virtually non-existent. The white rear fuselage band was an identification marking carried by Morotai-based aircraft during this period.

Doubt exists regarding the true identity of this aircraft. Though Gp Capt Caldwell recorded this machine as A58-464 in his log book, it has been ascertained that its actual identity was lost when the white band was painted on the rear fuselage, obscuring the serial number which was incorrectly repainted afterwards. The real A58-464 served with No. 8 OTU, RAAF and never saw operational service. Contemporary photographs suggest that the correct serial was A58-484.

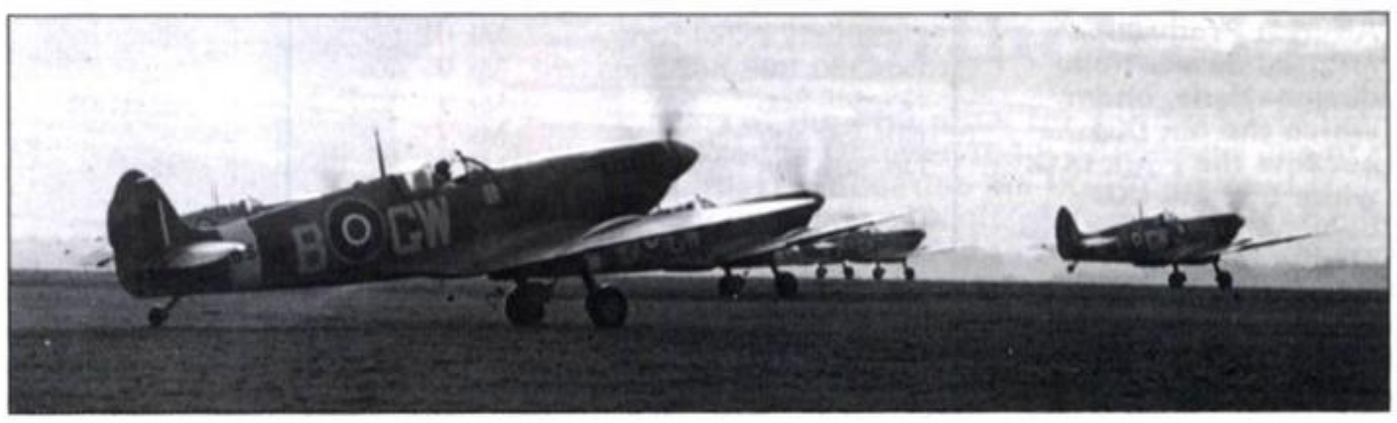
Enter the Mk IX

Below: As Mk IXs were expected to fly longer distances over occupied Europe and lacked the extra wing leading-edge fuel tanks fitted to the Mk VIIs and VIIIs, attempts were made to improve range performance. Various trial installations, including wing-mounted tanks from a P-51, were flown. This Mk IXC, from an unidentified unit on an RAF station in the depths of winter, 1943/44, carries the chosen design – a 50-Imp gal (227-litre) belly tank. Late-production Mk IXs had extra fuselage tanks installed.

Right: Armourers prepare 20-mm ammunition for Mk IXs during spring/early summer 1944. 'US' codes were carried by No. 56 Squadron, equipped with Mk IXs for just three months (from April to June 1944) between relinquishing its Hawker Typhoons and re-equipping with Tempests in mid-June. The aircraft coded 'AH' was with No. 332 (Norwegian) Squadron, which was to join the Second Tactical Air Force (2nd TAF) and cover the Normandy landings just weeks after this scene was recorded. In August No. 332 moved to France, flying Mk IXs for the duration of the war.

Above: One of the first units to re-equip with the Mk IX was No. 611 'West Lancashire' Squadron. These early production Mk IXCs are seen over south London in formation for RAF Biggin Hill's station photographer. Among roles added to the Spitfire's repertoire with the Mk IX were 'Diver' patrols to counter the German Fieseler Fi 103 (V-1) revenge weapon.

Below: Mk IXs were first sent to North Africa in December 1942 to counter the threat posed by Luftwaffe Fw 190s deployed to the theatre the previous month. This is a Mk IX of No. 94 Squadron, which spent the war in North Africa and Mediterranean, receiving Mk Vs in August 1943. Mk IXCs were flown between February and August 1944 and, after a stint with Mk Vs again, between February and April 1945.



routes from Italy. Under Operation Flax, the Allied air forces concentrated their attention against the airlift carrying supplies to the Axis forces. Scores of transport planes were shot down, gravely reducing the carrying capacity of the airlift. From then, the days of the Axis forces in North Africa were numbered, and early in May 1943 they capitulated.

The Spitfire VII in service

Because of the continuing lack of a high-altitude threat to Great Britain, production of the Mk VII had only a moderate priority. It was May 1943 before No. 124 Squadron at North Weald became operational with the variant. In August 1943 three Mk VIIs were based at Skeabrae in the Orkney Islands, to engage high-altitude reconnaissance aircraft attempting to photograph the fleet anchorage at Scapa Flow. Fighter squadrons based elsewhere in Great Britain were rotated through Skeabrae during their rest periods, and their pilots flew the Mk VIIs. There were few opportunities for them to go into action, but they served their purpose by acting as a deterrent.

In all, 140 Mk VIIs were built, the last being delivered in May 1944. In the spring of 1944, Nos 131 and 616 Squadrons converted to the Mk VII. During the preparations for the Normandy invasion their task was to prevent high-flying German reconnaissance aircraft from photographing the invasion ports.

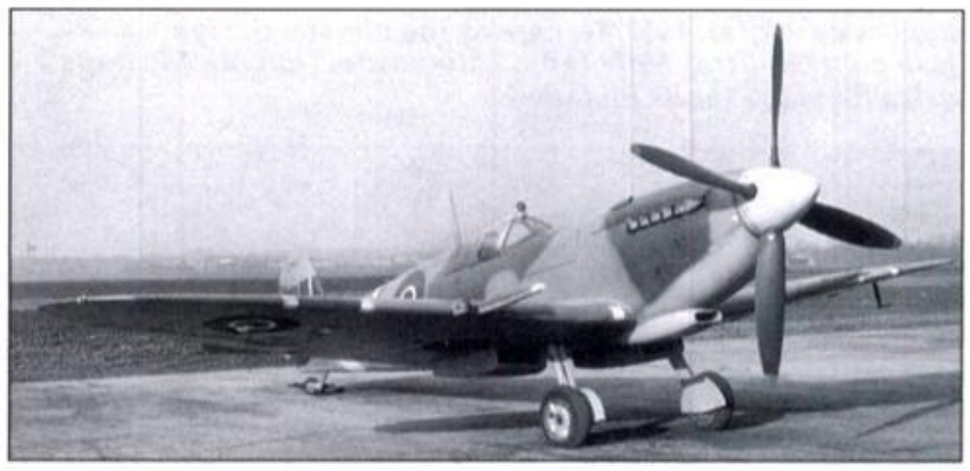
During the days immediately following the invasion, the Mk VII units provided top cover over the beachhead area.

Above: When this photograph was taken, in October 1942, No. 340 'Ile de France' Squadron (a Free French unit) had just re-equipped with Mk IXBs, having flown Mk Vs. These it kept for just five months before being rested at Drem and Turnhouse in Scotland, where it reverted to Mk Vs.

First Mk IX victor

Spitfire Mk IXC
In BR600, Plt Off Donald Kingaby of No. 64 Squadron became the first pilot to score a kill in a Mk IX when, on 30 July 1942, he downed an Fw 190 over Boulogne. This was a turning point for RAF Fighter Command which was now able to engage the 'Butcher Bird' on equal terms.

Above: Optimised for high-altitude operations, the HF.Mk IXC was powered by a Merlin 70, but lacked a pressurised cabin.



Above: Though the 'LF' designation of the LF.Mk IXC implied that it was intended for low-level operations, this was misleading. These aircraft were fitted with the Merlin 66 engine, the supercharger of which was designed to cut in at lower altitudes to provide optimum performance for engaging Fw 190s.

'Mk IXB'

As the Merlin 66-engined Mk IXs entered service in spring 1943, an official designation for the variant simply did not exist. Wishing to differentiate between these aircraft and 'standard' Mk IXCs, squadrons devised their own designations, namely 'Mk IXA' for the Mk IXC and 'Mk IXB' for the Merlin 66-powered aircraft. Later in 1943 the Ministry of Aircraft Production allotted new official designations, under which the Mk IXC became the F.Mk IXC, while the 'Mk IXB' became the LF.Mk IXC. The later Merlin 70-engined high-altitude variant was to be the HF.Mk IXC. By the time squadrons were notified of the change, the unofficial designations were well established.

Above: Most Packard-engined Mk XVIs were built with 'E' wings which held two 20-mm cannon and two 0.5-in (12.7-mm) machine-guns. Many had 'clipped' wings towards the war's end, like this No. 416 Squadron, RCAF example.

Peak deployment of Merlin-engined Spitfires, June 1944

(Unless otherwise stated, units operated in the fighter role. Units marked * operated a mixture of types that included Spitfires.)

Air Defence of Great Britain

No. 10 Group

Nos 1, 165 Sqns	Mk IX	Predannack
No. 126 Sqn	Mk IX	Culmhead
Nos 131, 616 Sqns	Mk VII	Culmhead

No. 11 Group

Nos 33, 74, 127 Sqns	Mk IX	Lympne
Nos 64, 234, 611 Sqns	Mk V	Deanland
Nos 80, 229, 274 Sqns	Mk IX	Detling
Nos 130, 303, 402 Sqns	Mk V	Horne
No. 345 Sqn	Mk V	Shoreham
No. 350 Sqn	Mk V	Friston
No. 501 Sqn	Mk IX	Friston

No. 12 Group

No. 504 Sqn	Mk V	Castletown, Digby, Acklington

No. 13 Group

No. 118 Sqn	Mk V	Skeabrae, Sumburgh

Second Tactical Air Force

No. 83 Group

(Mk IXs operated as fighters and fighter-bombers)

No. 125 Wing (Nos 132, 453, 602 Sqns)	Mk IX	Ford
No. 144 Wing (Nos 441, 442, 443 Sqns)	Mk IX	Ford
No. 126 Wing (Nos 401, 411, 412 Sqns)	Mk IX	Tangmere
No. 127 Wing (Nos 403, 416, 421 Sqns)	Mk IX	Tangmere

No. 84 Group

(Mk IXs operated as fighters and fighter-bombers)

No. 131 Wing (Nos 302, 308, 317 Sqns)	Mk IX	Chailey
No. 132 Wing (Nos 66, 331, 332 Sqns)	Mk IX	Bognor
No. 134 Wing (Nos 310, 312, 313 Sqns)	Mk IX	Appledram
No. 135 Wing (Nos 222, 349, 485 Sqns)	Mk IX	Selsey
No. 145 Wing (Nos 329, 340, 341 Sqns)	Mk IX	Merston

No. 85 Group

(Mk IXs operated as fighters and fighter-bombers)

No. 56 Sqn	Mk IX	Newchurch
No. 124 Sqn	Mk VII	Bradwell Bay

Air Spotting Pool

No. 26 Sqn	Mk V	Lee on Solent (gunfire spotting)
No. 63 Sqn	Mk V	Lee on Solent (GS)

Coastal Command

No. 275 Sqn	Mk V	Warmwell* (search and rescue)
No. 276 Sqn		Portreath* (SAR)
No. 277 Sqn	Mk V	Shoreham* (SAR)
No. 278 Sqn	Mk V	Bradwell Bay* (SAR)
No. 519 Sqn	Mk VI	Wick* (Met)

Army Co-operation Units

No. 288 Sqn	Mk V	Collyweston*

Mediterranean Air Command

Italy

Nos 32, 253 Sqns	Mk IX	Foggia
Nos 73, 87 Sqns	Mk V, IX	Foggia
No. 43 Sqn	Mk IX	Nettuno
Nos 72, 111	Mk IX	Largo
No. 145 Sqn	Mk VIII	Lago
No. 40 SAAF, 225 Sqns	Mk V, IX	Lago (Tac. Recon)
Nos 92, 417, 601 Sqns	Mk VIII	Venafro
No. 208 Sqn	Mk IX	Venafro (TacR)
No. 93 Sqn	Mk IX	Tre Canelli
Nos 249, 1435 Sqns	Mk IX	Grottaglie
No. 241 Sqn	Mk IX	Trigno (TacR)
No. 318 Sqn	Mk V	Trigno (TacR)

No. 7 SAAF Fighter Wing

Nos 1, 2, 4, 7 Sqns, SAAF	Mks V, IX	based in Italy

Corsica

Nos 154, 232, 242, 243 Sqns	Mk IX	Poretta
Nos 237, 238, 451 Sqns	Mk IX	Serragia
No. 328 Sqn	Mk IX	Borgo,

Malta

No. 185 Sqn	Mk IX	Hal Far

Middle East Command

Libya

No. 94 Sqn	Mk IX	Bu Amud
No. 335 Sqn	Mk V	Bersis

Egypt

No. 213 Sqn	Mk IX	Idku
No. 336 Sqn	Mk IX	Mersa Matruh

Aden

No. 3 Sqn SAAF	Mk V	Khormaksar

Air Command, Southeast Asia

No. 222 Group (Ceylon)

No. 17 Sqn	Mk VIII	Vavuyina
No. 273 Sqn	Mk VIII	Ratmalana

Eastern Air Command (India)

Nos 67, 155 Sqns	Mk VIII	Baigachi

No. 221 Group (India)

No. 81 Sqn	Mk VIII	Khumbirgram
No. 607 Sqn	Mk VIII	Imphal
No. 615 Sqn	Mk VIII	Palel

No. 224 Group (India)

No. 152 Sqn	Mk VIII	Palel
No. 136 Sqn	Mk VIII	Chittagong

No. 1 Fighter Wing (Australia)

Nos 54, 452, 457 Sqns	Mk VIII	Darwin area

Engine and propeller
Driving the four-bladed Rotol Jablo propeller in BS459 was a Merlin 61. Some F.Mk IXs were powered by either a Merlin 63 or 63A; different variants were fitted to LF.Mk IXs and HF.Mk IXs, optimised for Fw 190 engagement and high-altitude interception, respectively.

Late-production Mk IXs
As Mk IX production progressed, various improvements were introduced, including a 72-Imp gal (327-litre) fuel tank in the rear fuselage, a broad chord rudder and the 'rear-view fuselage' with a 'bubble' canopy. This latter change reduced fuselage tank capacity to 64 Imp gal (291 litres).

Spitfire Mk IX versus Fw 190
At Duxford, the Air Fighting Development Unit (AFDU) compared a captured Focke-Wulf Fw 190 with a fully operational Spitfire Mk IX for speed and manoeuvrability at heights up to 25,000 ft (7620 m). The Spitfire IX at most heights was slightly faster. During climbs at various heights up to 23,000 ft (7000 m), with both aircraft flying under maximum continuous climbing conditions, little difference was found between the aircraft, though on the whole the Spitfire was slightly better. The Fw 190 was faster than the Mk IX in a dive, had a superior roll rate and its initial acceleration was better than that of the Spitfire, except in level flight at such altitudes where the Spitfire has a speed advantage and then, providing the Spitfire was cruising at high speed, there was little to choose between the aircraft. The general impression gained by pilots taking part in the trials was that the Mk IX compared favourably with the Fw 190.

Camouflage
BS459 is finished in the standard RAF day fighter camouflage introduced in May 1942. Ocean Grey and Dark Green were the most commonly used upper surface colours; undersurfaces were Medium Sea Grey. The aircraft's spinner was Sky Blue, as were the Fighter Command recognition band on the rear fuselage and the unit codes. Additional markings include the Polish national insignia on the engine cowling and No. 306 Squadron's 'bird and bear' emblem.

Spitfire F.Mk IXC No. 306 Squadron Northolt, 1943

Part of the fifth order for Spitfire Mk IA/IBs placed in October 1940, BS459 was one of the earliest production Mk IXs. Completed at Supermarine's Eastleigh factory in September 1942, it was issued to No. 306 'Torunski' Squadron on 25 September. Based at Northolt, No. 306 was engaged in daylight sweeps over Europe in 1943. BS459 failed to return from operations on 26 January 1943 and is believed to have collided with sister aircraft BS241 over the English Channel.

Gun armament
Most Mk IXs were built with the six gun 'C' wing carried over from the Mk VC. (A few Mk IXs converted from Mk VCs carried four cannon.) Later production aircraft and the bulk of Mk XVI production had the 'E' wing, in which cannon were fitted in the outer cannon bays, each of the two inner bays being occupied by a 0.5-in (12.7-mm) US Browning.

Cooling systems
With Merlin 60-engined Spitfires came symmetrical underwing radiator intakes, first seen on the Spitfire Mk III. Merlin 60 series engines incorporated a supercharger intercooler with its own radiator under the port wing. The oil cooler, which had its own small intake on earlier marks, was incorporated in the same housing. The starboard intake fed the Merlin's cooling system.

Fighter-bombers
In the fighter-bomber role, which became increasingly important after D-Day, Spitfire Mk IXs were equipped to carry up to 1,000 lb (454 kg) of bombs. Wing racks were each able to hold a 250-lb (113-kg) bomb; a centreline rack had a 500-lb (227-kg) capacity. On Mk IXEs, wing buckling was an early problem, where the bomb rack was fitted directly below the cannon bay.

Receiving Mk IXs at the end of 1943, No. 241 Squadron saw out the war in Italy, engaged in tactical and shipping reconnaissance, escort and ground attack duties. Here two of its aircraft, finished in RAF temperate camouflage, are seen over Cassino, March 1944.

Above: This Mk IX was operated by the 309th Fighter Squadron, 31st Fighter Group of the US 12th Air Force and is pictured at Castel Volturno near Cassino, Italy in March 1944. Where more than 26 aircraft were assigned to a squadron – often the case after late 1943 – double code letters were assigned to the additional aircraft. The 309th's 'WZ-GG' is likely to have flown alongside an aircraft coded 'WZ-G'.

Below: Pictured at Appledram in June 1944, this LF.Mk IX of No. 310 (Czech) Squadron has been levelled off with a tail jack for the harmonisation of its gunsight and guns. Note the hastily applied 'D-Day' stripes and the serial number moved to a position on the fin.

'Top cover' proved to be a relative term, however, for the Luftwaffe presented no credible high-altitude threat. The Spitfire VIIs flew the highest defensive patrols, though at altitudes of only about 20,000 ft (6100 m). After a few days, the Mk VIIs operated in the same way as other Spitfire variants, carrying out low-altitude patrols and going down to strafe road and rail targets. The fighters' pointed wingtips were replaced with the standard rounded tips to improve manoeuvrability at low altitude.

Soon after, the Mk VII's larger internal fuel tankage gave the variant a new lease of life, as a bomber escort. The longest such mission was on 11 August, when No. 131 Squadron escorted Lancasters making a daylight attack on the submarine pens at La Pallice. That 690-mile (1110-km) round trip was close to the Mk VII's maximum radius of action, leaving little fuel to go into action if enemy fighters engaged the force. The escorts flew above their charges throttled well back, hoping that by their mere presence they would deter enemy fighters. Fortunately for the Mk VII pilots, the stratagem succeeded.

In January 1945 the Spitfire VII passed out of front-line service, having had few chances to demonstrate its ability as a high-altitude interceptor.

With the Mk IX available in large numbers, there was reduced urgency to get the fully engineered Mk VIII into mass production. The first Mk VIIIs appeared in November 1942, but another seven months elapsed before production of this variant exceeded 50 per month. It was decided that the entire production of Mk VIIIs should be sent overseas, to units in the Mediterranean, Southeast Asia, southwest Pacific and Australia theatres. The need to ship the aircraft to those distant theatres further delayed the appearance of the variant in front-line service. The first unit to receive Mk VIIIs, No. 145 Squadron based in Malta, became operational only in June 1943.

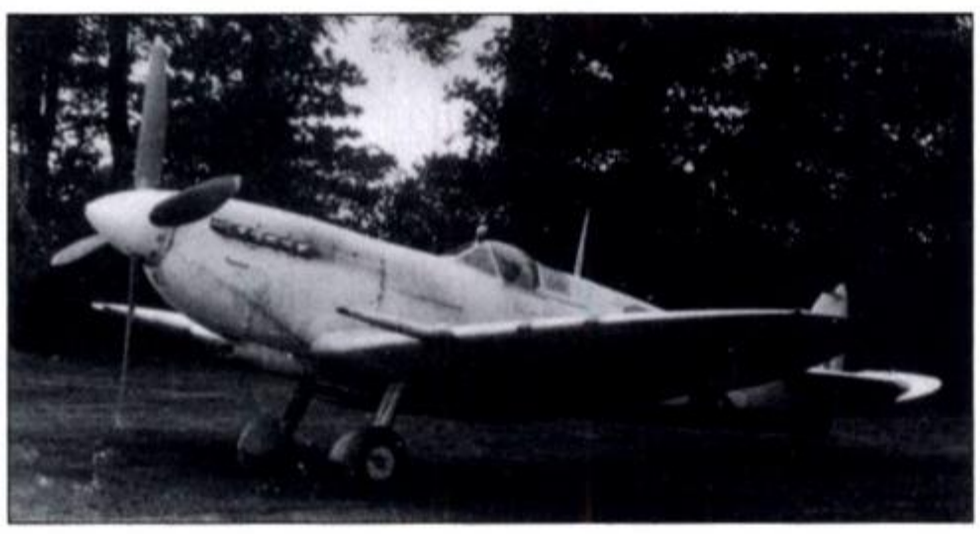
In addition to the deliveries of Mk VIIIs to RAF units in Italy, the US Army Air Forces received 55 examples which operated with Mk Vs in the 308th Squadron of the 31st Fighter Group; the other squadrons in the group flew Mk IXs and Mk Vs.

Mk VIIIs in the Far East

In Southeast Asia the first Mk VIIIs arrived toward the end of 1943. Nos 81 and 152 Squadrons based at Alipore and Baigachi in eastern India converted to the new variant, soon followed by other fighter units in the theatre.

D-Day Spitfires

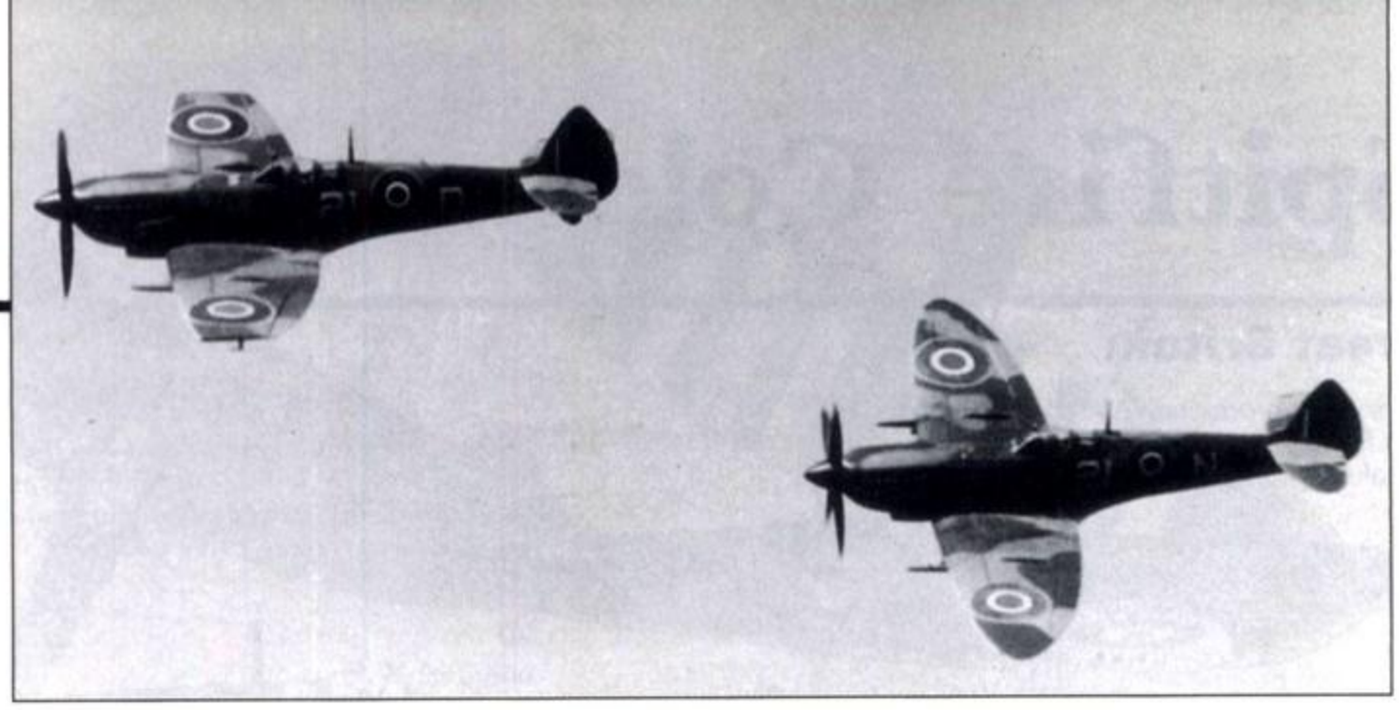
Melsbroek, near Brussels, was the base in autumn 1944 for modified FR.Mk IXC armed reconnaissance aircraft operated by No. 16 Squadron. Painted pale pink, these aircraft were used for low-altitude photography. 'Invasion' stripes were painted under the rear fuselage and the undersurfaces of the wings. Oblique cameras were fitted and the 20-mm cannon were often removed. Fifteen Mk IXs were also converted to PR.Mk IX for unarmed high-altitude work, pending the arrival of the definitive Merlin-engined reconnaissance variant, the PR.Mk XI. First used operationally in November 1942, it was a PR.Mk IX that took the famous pictures of the Ruhr dams breached by No. 617 Squadron in May 1943.



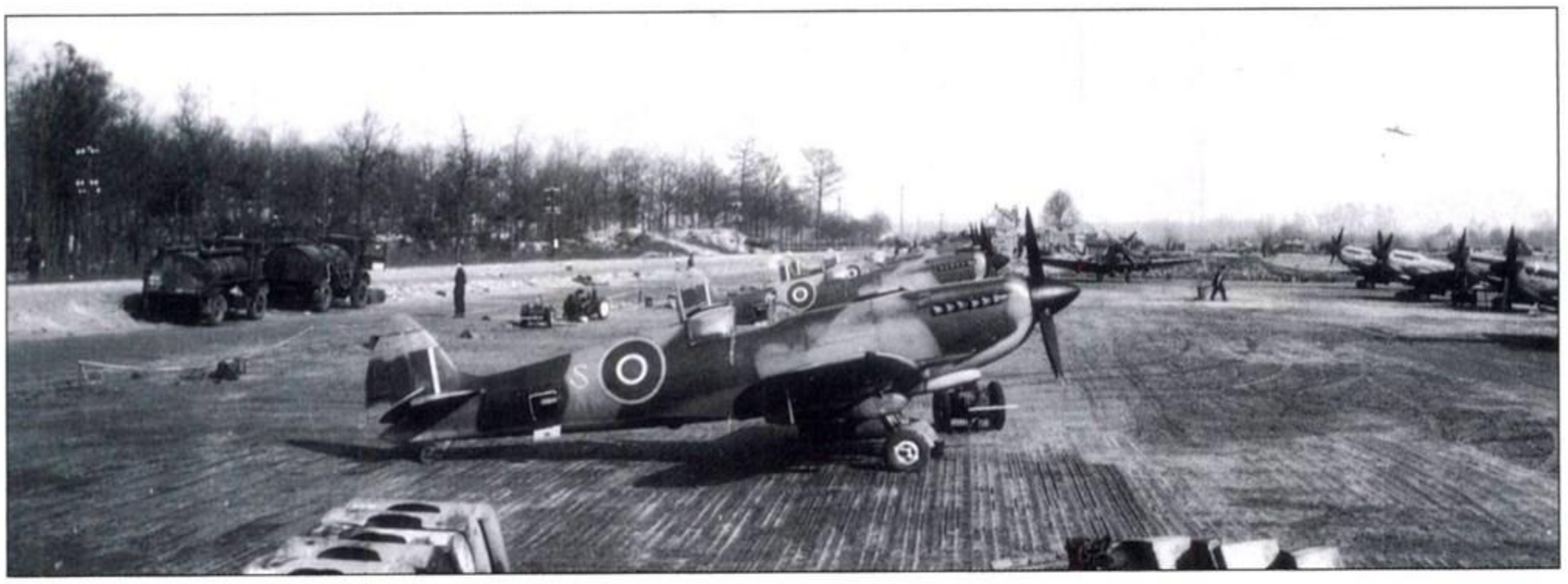
Above: During the final year of the war, once air supremacy had been secured, the Merlin-engined Spitfires moved progressively to the fighter-bomber role. This German photograph shows a Spitfire strafing a ground target in Normandy in 1944.

Mk XVIs over Europe

Produced alongside Mk IXs at the Castle Bromwich Aircraft Factory, Packard Merlin-engined Mk XVIs carried the same modifications introduced in the Mk IX during production. The first examples entered service in September 1944 with No. 403 Squadron, RCAF, the variant staying in production until the end of the war and serving exclusively with RAF units in the north European theatre. Often referred to as 'LF.Mk XVIs' (as their Merlin 266s were simply US-built Merlin 66s), most had 'E' wing armament and many flew with 'clipped' wings.



Above: Mk XVIEs of No. 443 Squadron, RCAF based at Diepholz in 1945, clearly show the effect of 'clipped' wings on the Spitfire's appearance. With the 'E' wing fitted, two Browning machine-guns were installed inboard of the cannon, which are discernible in this photograph. Also of note are the wing roundels, which have a non-standard yellow outer ring.



Above: Newly delivered 'clipped'-wing Mk XVIEs of No. 74 Squadron are parked on the PSP (pierced steel planking) at Schijndel in Holland in March 1945. Although they have yet to have the unit's '4D' code letters applied, a makeshift code appears to have been applied to the nearest aircraft, TB859. Some of the aircraft are bombed-up, ready for an operation with two 250-lb (113-kg) bombs under the wings and a 500-lb (227-kg) weapon under the fuselage, the maximum load it could carry against short-range targets. Stacked in the foreground ready for use are several 30-Imp gal (136-litre) drop tanks. Also in evidence are bowsers with fuel for the aircraft, and 'trolley accs' with which to start the Packard Merlins.

Initially, there was little air activity over the theatre. The Japanese Army Air Force was seriously overstretched and had to conserve its strength. The period of relative calm ended on 6 February 1944, when Japanese ground forces went on the offensive in the Arakan area. The attackers used their well-tried tactic of infiltrating forces through the jungle to get behind Allied positions, to sever their supply routes and force the troops to retreat. General William Slim, commander of the British 14th Army, had an effective answer to this enemy stratagem: he ordered the 5,000 troops

Notable RAF Nines

Spitfire Mk IXC
Erroneously serialled BF273 at the time, this Mk IX (BS273) was flown by Flg Off Emanuel Galitzine of the RAF's High Altitude Flight during combat with a Luftwaffe Ju 86P 43,500 ft (13259 m) over Southampton on 12 September 1942. This was the highest recorded air combat of World War II. Finished in PR Blue overall, the aircraft had its machine-guns, armour and other unnecessary equipment removed.

Spitfire Mk IXC
Sqn Ldr Stanislaw Skalski, OC of the Polish Fighting Team attached to No. 145 Squadron, flew EN315 in Tunisia in spring 1943. By the end of the war in Europe, Skalski had 21 victories (some sources say 24), three of which were gained while flying Mk IXs with the PFT. The PFT was the first 'unit' to operate Mk IXs in North Africa.

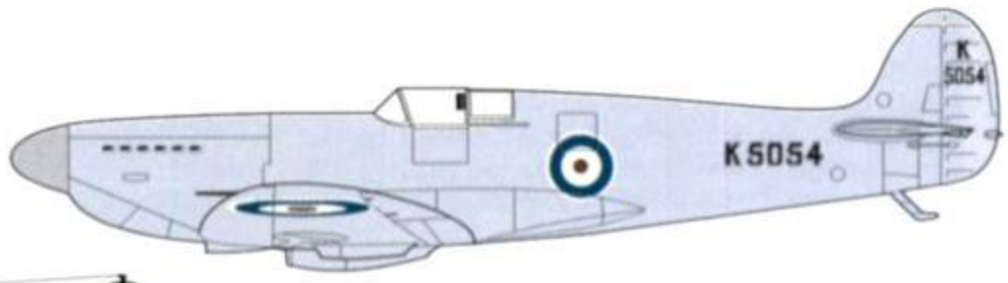
Spitfire Mk IXC
EN398 is arguably the Spitfire that can be credited with the most kills. Wg Cdr 'Johnnie' Johnson, OC Kenley Wing in early 1943, shot down 14 aircraft in '398, the first in April. In June, flown by Sqn Ldr Robert McNair while Johnson was on leave, the Mk IX was credited with another victory, bringing the aircraft's total to 15 destroyed. EN398 survived the war, but was scrapped in 1949.

Spitfire Colours

Great Britain

Below: First production Mk Is, like K9787, were finished in Dark Earth/Dark Green with aluminium undersides.

Right: Unlike other RAF fighter prototypes of the day, the Spitfire prototype, K5054, was finished in high-gloss Seaplane Grey by Supermarine.



Right: No. 602(F) Sqn Mk I with Type 'A' roundels and grey squadron codes, late 1939/ early 1940. Night and white undersurfaces.

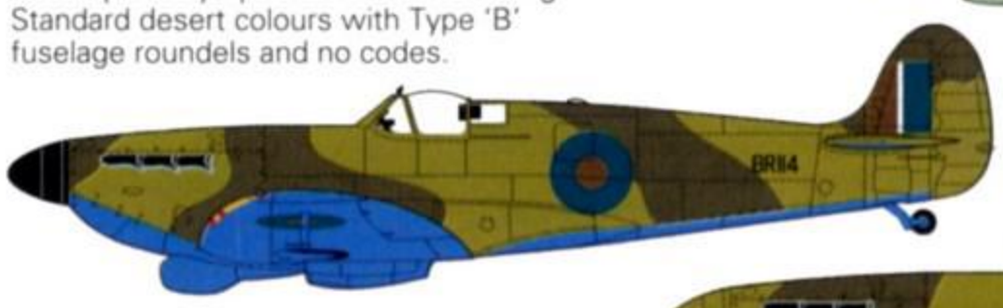
Below: Sky undersurfaces were introduced June 1940, with grey codes. Black spinner retained. This No. 65(F) Sqn aircraft is in typical late Battle of Britain scheme.

Below: This No. 72 Sqn aircraft shows the late 1940 addition of Sky recognition band.

Below: Dark Green and Ocean Grey, adopted by Fighter Command in 1941, is shown on this No. 64 Sqn aircraft.

Below: Medium Sea Grey replaced Sky Blue on undersurfaces in late 1941. This is a No. 350 (Belgian) Sqn aircraft.

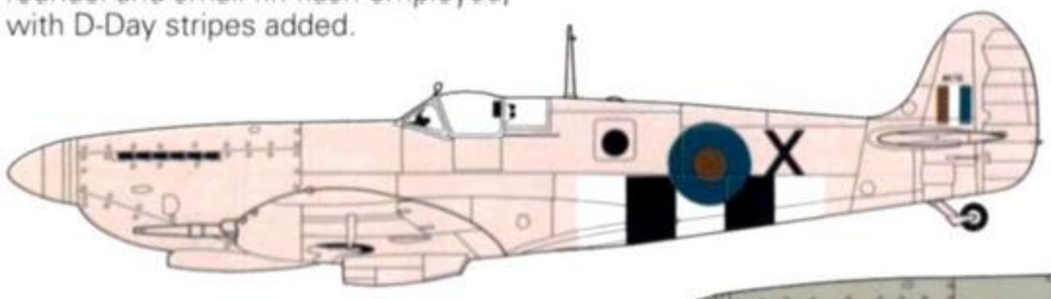
Below: Mk VC modified by No. 103 MU at Aboukir, Egypt for high-altitude Ju 86 interception by Special Performance Flight. Standard desert colours with Type 'B' fuselage roundels and no codes.



Below: Dark Earth/Middle Stone/Azure Blue desert camouflage, as applied to Mk Vs in North Africa, is seen on a No. 225 Sqn Mk VC.

Below: Mk IX (EN398 with 'JE-J' codes of Wg Cdr 'Johnnie' Johnson) in RAF Fighter Command day camouflage (Ocean Grey and Dark Green) with Sky spinner, fuselage band and unit code letters.

Below: Armed reconnaissance FR.Mk IX of No. 16 Sqn, Belgium in low-level pink/off-white colour scheme. Type 'B' roundel and small fin flash employed, with D-Day stripes added.

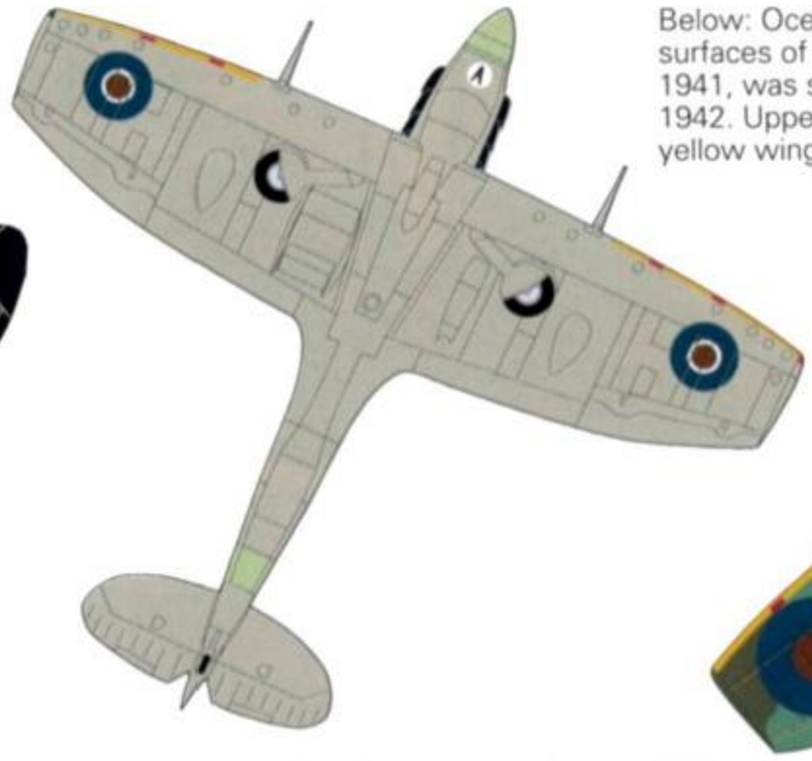


Below: Medium Sea Grey upper surfaces and PRU Blue undersurfaces were applied to Mk VIIs, including this Culmhead Wing aircraft in 1944.

Below: South East Asia Command colours (Foliage Green/Earth Brown/Medium Sea Grey) on a Mk VIII of Burma Command Flight, Mingaladon, 1945.

Right: Dark Green and Dark Earth camouflage on a Mk I, with a Sky Blue spinner, as introduced in late 1940.

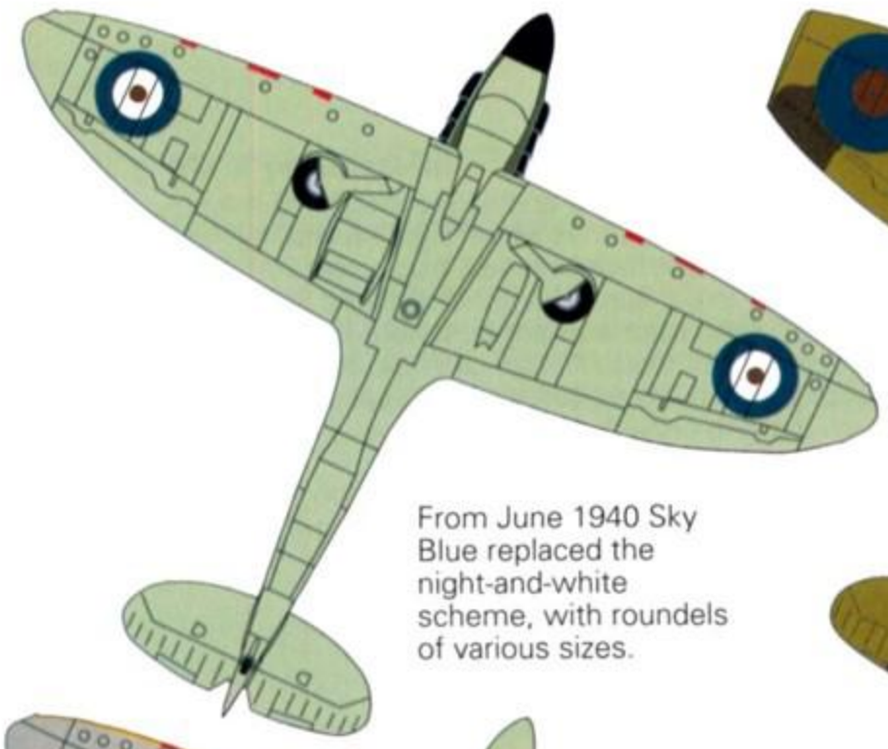
Below: Ocean Grey and Dark Green on the upper surfaces of this 'clipped'-wing Mk VB, adopted during 1941, was standard on production aircraft from May 1942. Upper surface wing roundels were of Type 'B'. The yellow wing leading edge was for recognition purposes.



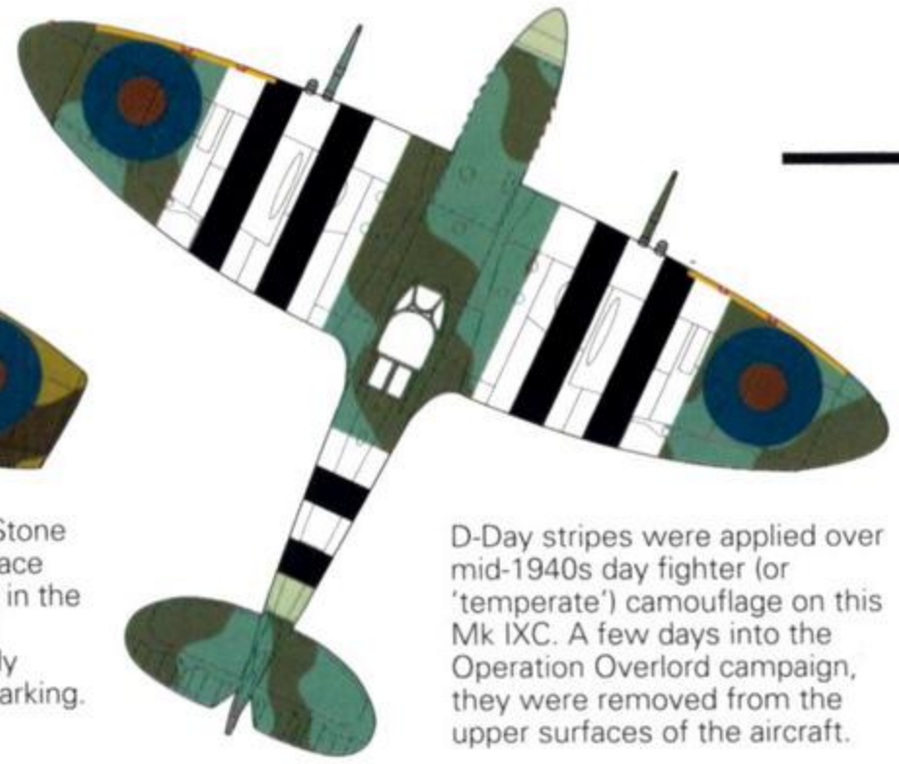
Above: Night/white undersurfaces were introduced in late 1938/early 1939, becoming standard on Fighter Command Spitfires between April 1939 and June 1940. Roundels were omitted.

Above: Medium Sea Grey undersurfaces with Type 'C' roundels, the latter replacing the earlier Type 'A' roundels, was standard from May 1942 on home-based and Northern Europe-based RAF Spitfires. This 'clipped'-wing Mk VB has its individual code letter in black on a white circle under its nose.

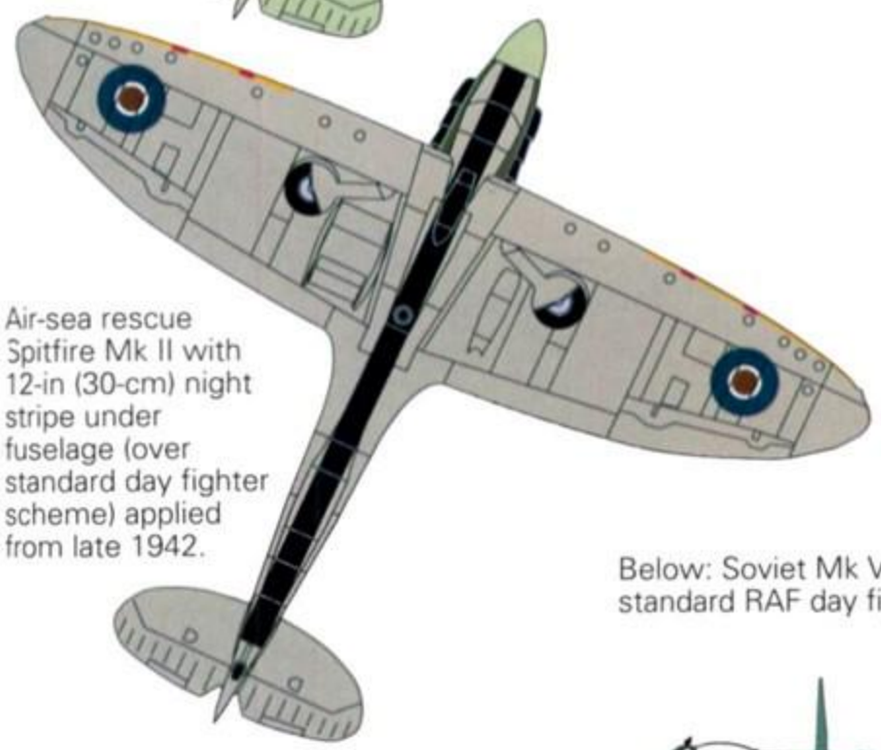
From June 1940 Sky Blue replaced the night-and-white scheme, with roundels of various sizes.



Dark Earth and Middle Stone made up the upper surface camouflage on Spitfires in the Mediterranean. The red spinner was a commonly applied Allied theatre marking.



D-Day stripes were applied over mid-1940s day fighter (or 'temperate') camouflage on this Mk IXC. A few days into the Operation Overlord campaign, they were removed from the upper surfaces of the aircraft.



Air-sea rescue Spitfire Mk II with 12-in (30-cm) night stripe under fuselage (over standard day fighter scheme) applied from late 1942.

United States

Left: This 309th FS, 31st FG aircraft shows how RAF 'temperate' camouflage was retained on US 8th Air Force Mk VBs. The cocarde was simply painted over the RAF roundel. The Sky Blue band was retained.

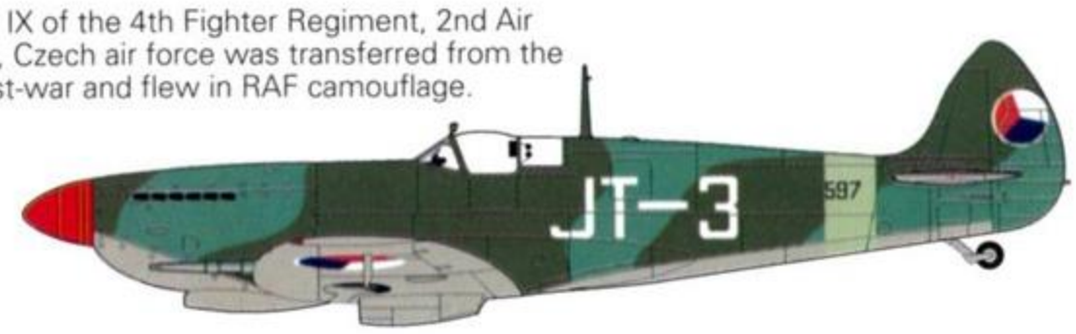
Soviet Union

Below: Soviet Mk Vs were delivered in standard RAF day fighter colours.

Overall-green adorned the local two-seat Mk IX UTI conversions from ex-RAF aircraft for the Voyenno-Vozdushnyye Sily (V-VS).

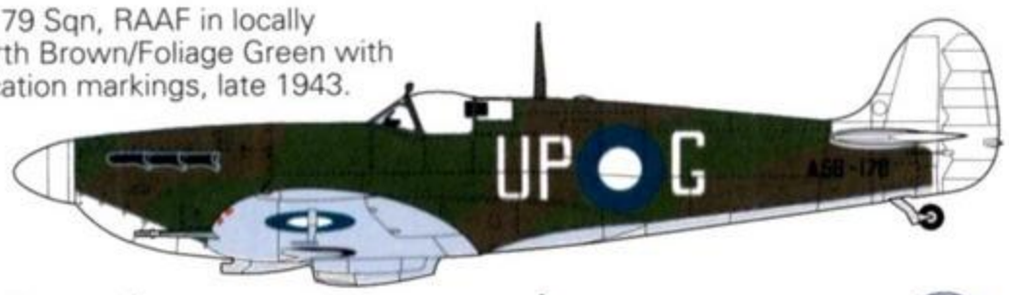
Czechoslovakia

This Mk IX of the 4th Fighter Regiment, 2nd Air Division, Czech air force was transferred from the RAF post-war and flew in RAF camouflage.



Australia

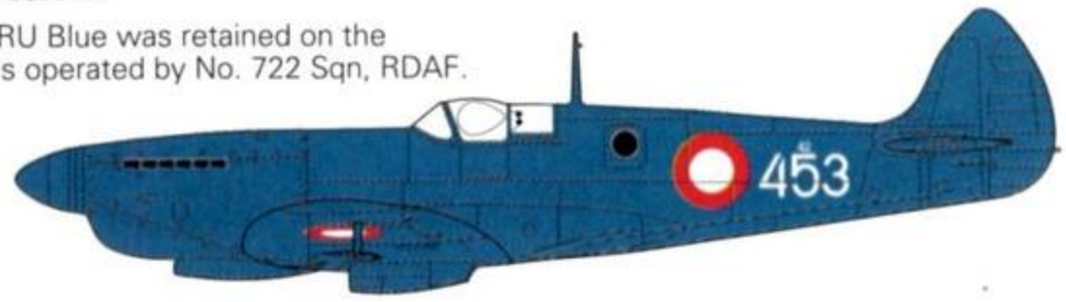
Mk VC of No. 79 Sqn, RAAF in locally developed Earth Brown/Foliage Green with white identification markings, late 1943.



In May 1944, all camouflage was removed from RAAF Spitfires. This is a No. 85 Sqn Mk VC.

Denmark

Overall PRU Blue was retained on the PR.Mk XIs operated by No. 722 Sqn, RDAF.

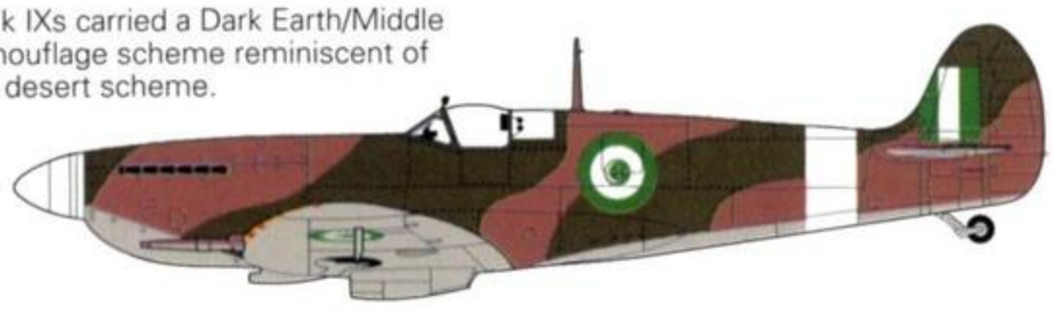


Belgium

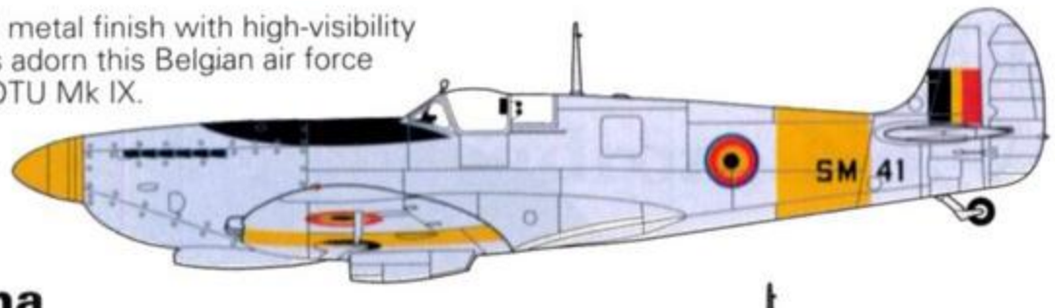
This late-production 'clipped'-wing Mk XVIE was with No. 350 Sqn, Fassburg, Germany in late 1945. Belgian national markings have been simply painted over the aircraft's original RAF markings.

Egypt

Egypt's Mk IXs carried a Dark Earth/Middle Stone camouflage scheme reminiscent of the RAF's desert scheme.



A natural metal finish with high-visibility markings adorn this Belgian air force Spitfire OTU Mk IX.

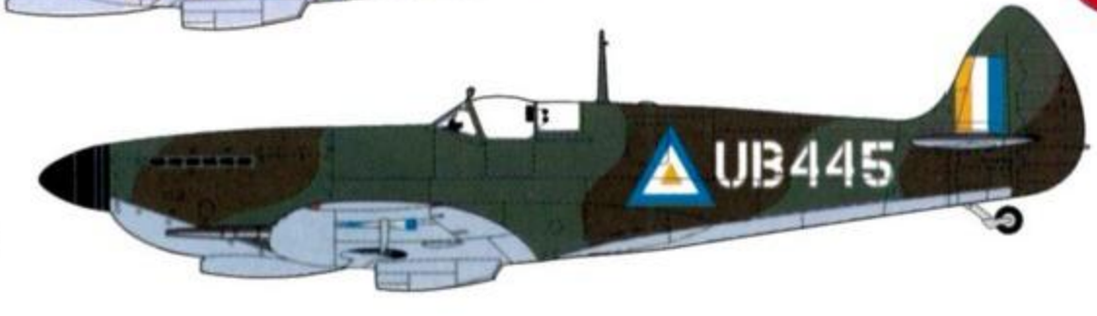


France (Armée de l'Air)

Mk IXs operated by the Armée de l'Air in Algeria during 1950 were stripped of paint and carried minimal markings.

Burma

Burma's ex-Israeli Mk IXs were camouflaged in green and brown, similar to RAF SEAC colours, with blue undersurfaces.

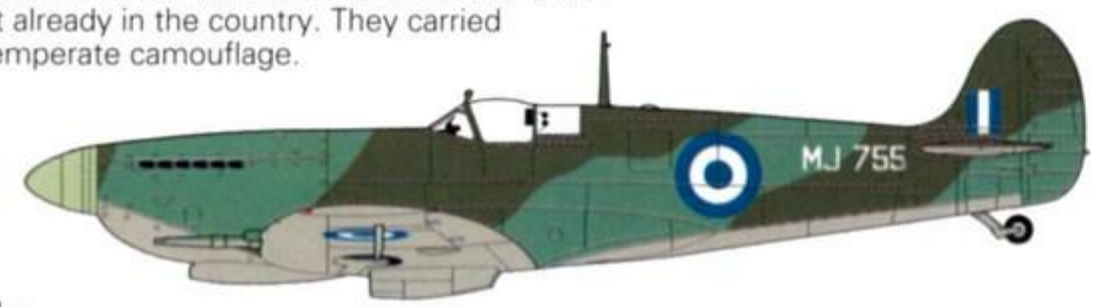


Germany

In common with other captured Allied types, this Spitfire was finished in overall Olive Drab with solid yellow undersides.

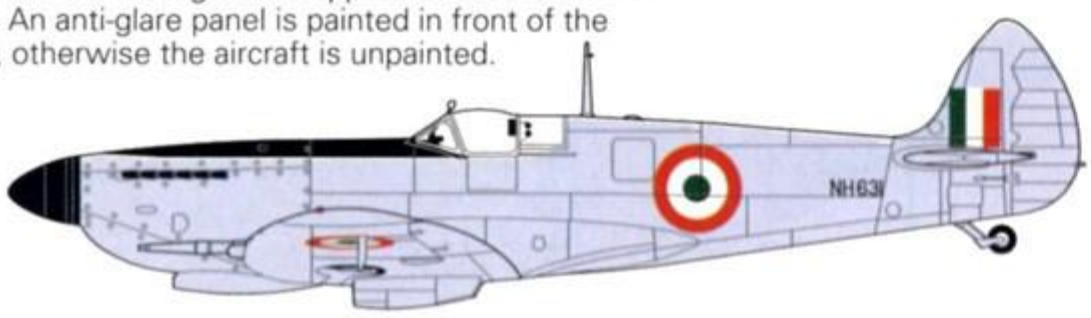
Greece

Greece's Mk IXs delivered after the war were RAF aircraft already in the country. They carried RAF temperate camouflage.



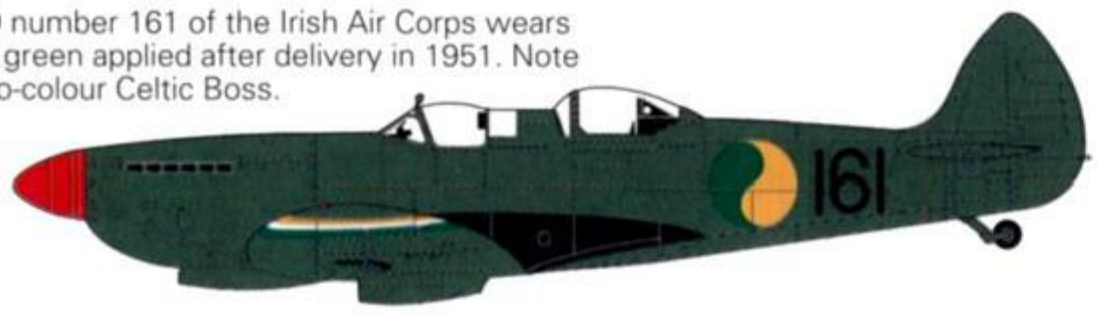
India

Basic national markings were applied to India's Mk VIII aircraft. An anti-glare panel is painted in front of the cockpit, otherwise the aircraft is unpainted.

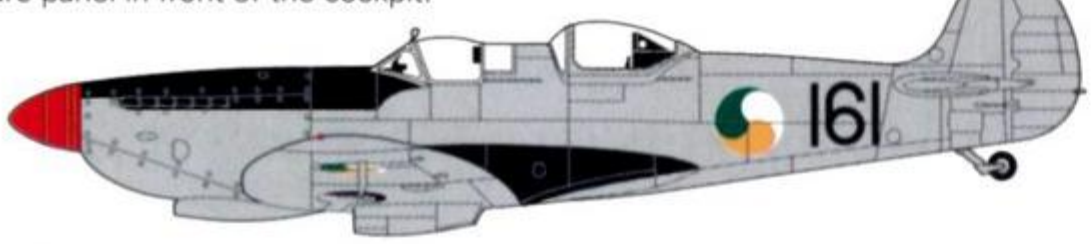


Ireland

T.Mk 9 number 161 of the Irish Air Corps wears overall green applied after delivery in 1951. Note the two-colour Celtic Boss.

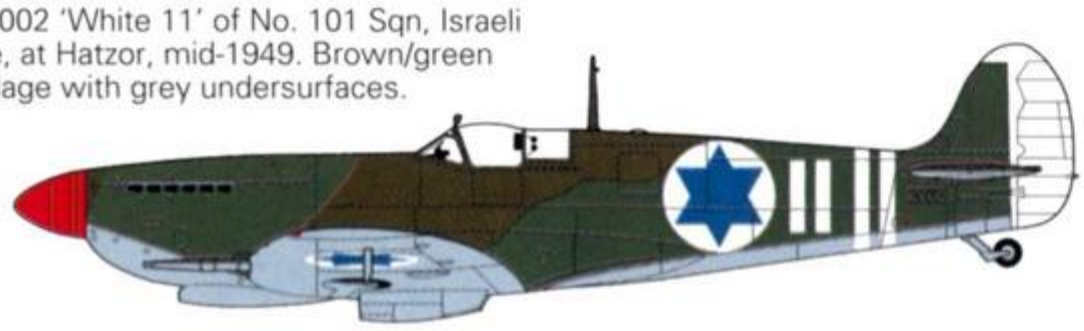


The same aircraft in late 1950s guise features three-colour boss, natural metal finish and an anti-glare panel in front of the cockpit.

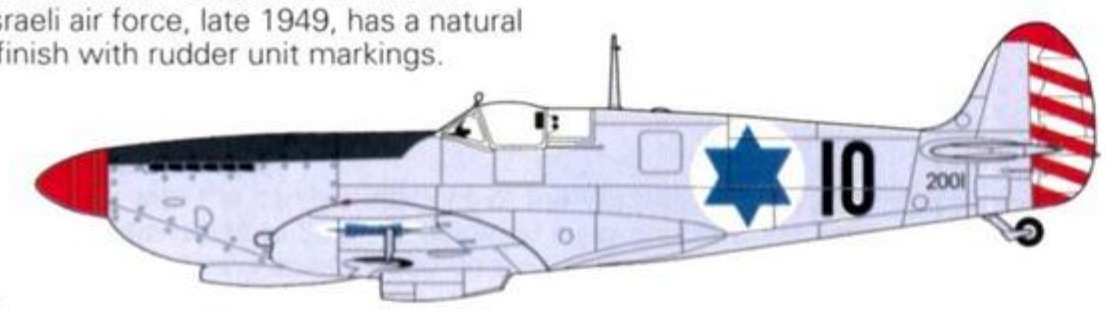


Israel

Mk IX 2002 'White 11' of No. 101 Sqn, Israeli air force, at Hatzor, mid-1949. Brown/green camouflage with grey undersurfaces.

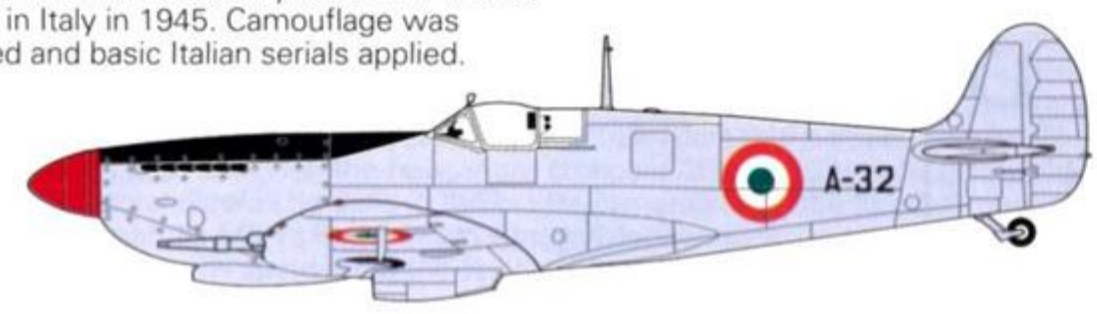


Spitfire Mk IX 2001 'Black 10' of No. 101 Sqn, Israeli air force, late 1949, has a natural metal finish with rudder unit markings.



Italy

Italy's air force took delivery of ex-RAF Mk IXs already in Italy in 1945. Camouflage was removed and basic Italian serials applied.



The Netherlands

Overall Green was applied to Mk IXCs employed by the Royal Netherlands East Indies Air Force Spitfires. This aircraft carries the markings of No. 322 Sqn, Semarang, 1949.

No. 322 flew this natural metal T.Mk 9 from Soesterberg.

Norway

Like Denmark, Norway operated ex-RAF PR.Mk XIs, which retained their wartime overall-PRU Blue scheme.

Flying this ex-RAF Mk IX in its 'as delivered' camouflage scheme, No. 331 Sqn was based at Vaernes in 1951.

Portugal

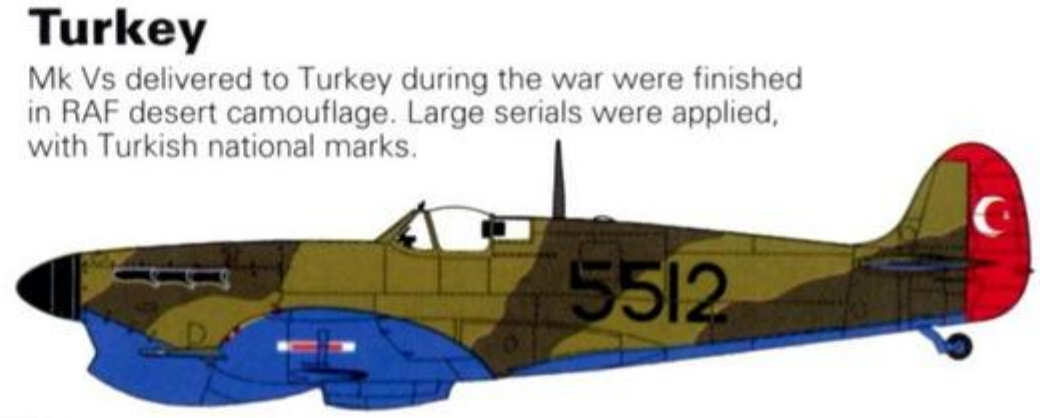
This Mk V was among the ex-RAF machines delivered to the Portuguese air force in standard RAF Ocean Grey and Dark Green camouflage.

South Africa

British standard Dark Green covered the upper surfaces of SAAF Mk IXs post-war. This No. 1 Sqn aircraft was based at Waterkloof in 1950.

Turkey

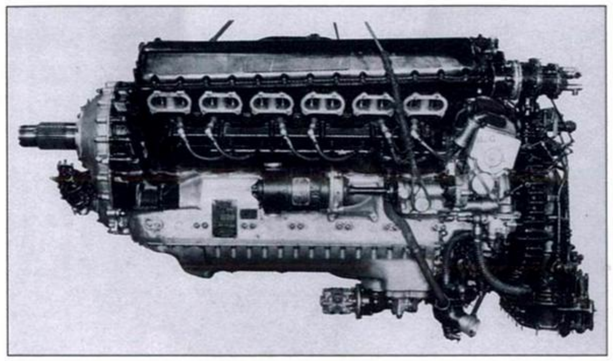
Mk Vs delivered to Turkey during the war were finished in RAF desert camouflage. Large serials were applied, with Turkish national marks.



Yugoslavia

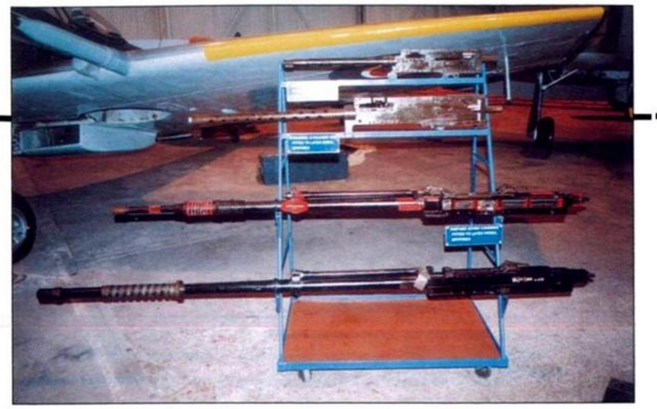
Under the control of the RAF, No. 352 Sqn, Balkan air force flew tropicalised Mk Vs in standard RAF 'temperate' camouflage with Yugoslav markings.

Inside the Spitfire Mk IX

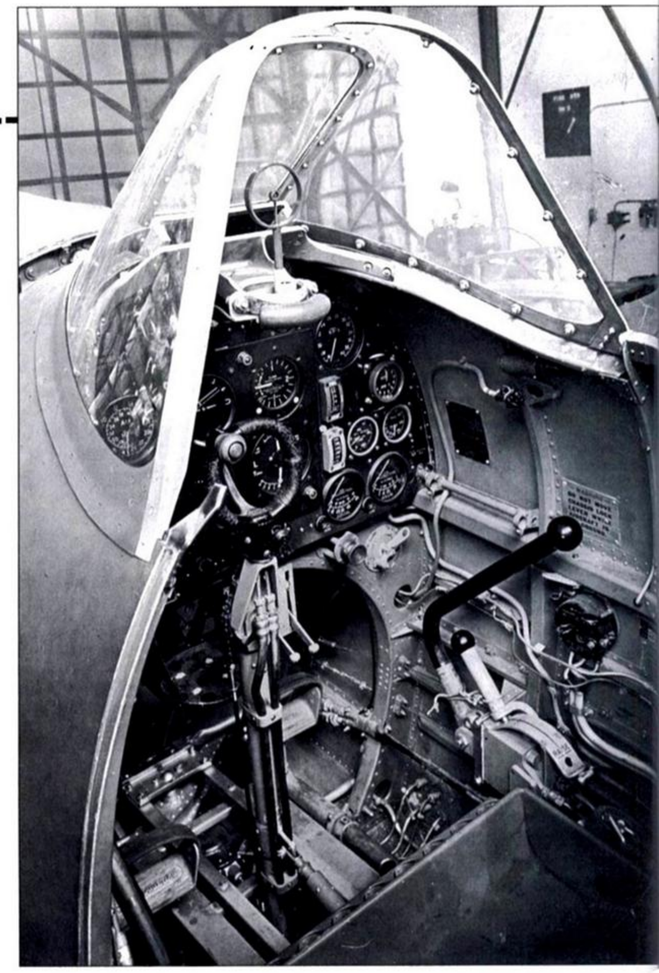


Left: Merlin IIIs were installed in late-production Spitfire Mk Is. Throughout the development of the Merlin-engined Spitfires, the cubic capacity of the engine remained unchanged. Power increases were gained largely through supercharger development.

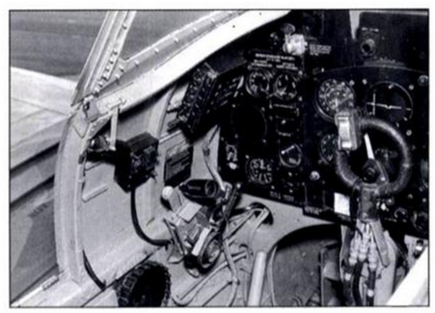
Right: Although wooden and metal propellers were fitted to Spitfires, most had Jablo airscrews.



Above: The three main gun types fitted to Spitfires were, from the top: the 0.303-in (7.7-mm) Browning machine-gun (mounted in 'A', 'B' and 'C' wings); the 0.5-in (12.7-mm) US Browning machine-gun ('E' wings); and two examples of the 20-mm Hispano cannon ('B', 'C' and 'E' wings).

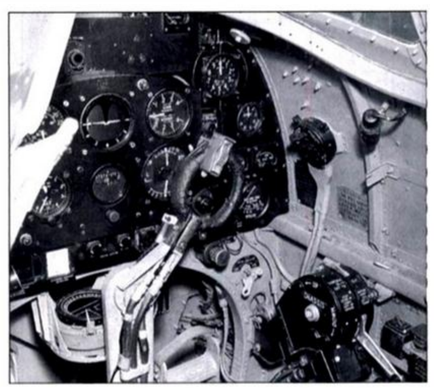


Above: In this cockpit of an early production Spitfire Mk I, note the ring-and-bead gun sight and the absence of an armoured windscreen. The introduction of the reflector gunsight at the beginning of the war was a major advance. It, in turn, was superseded by the bulky but potentially very accurate gyro gunsight introduced in the Mk IX.

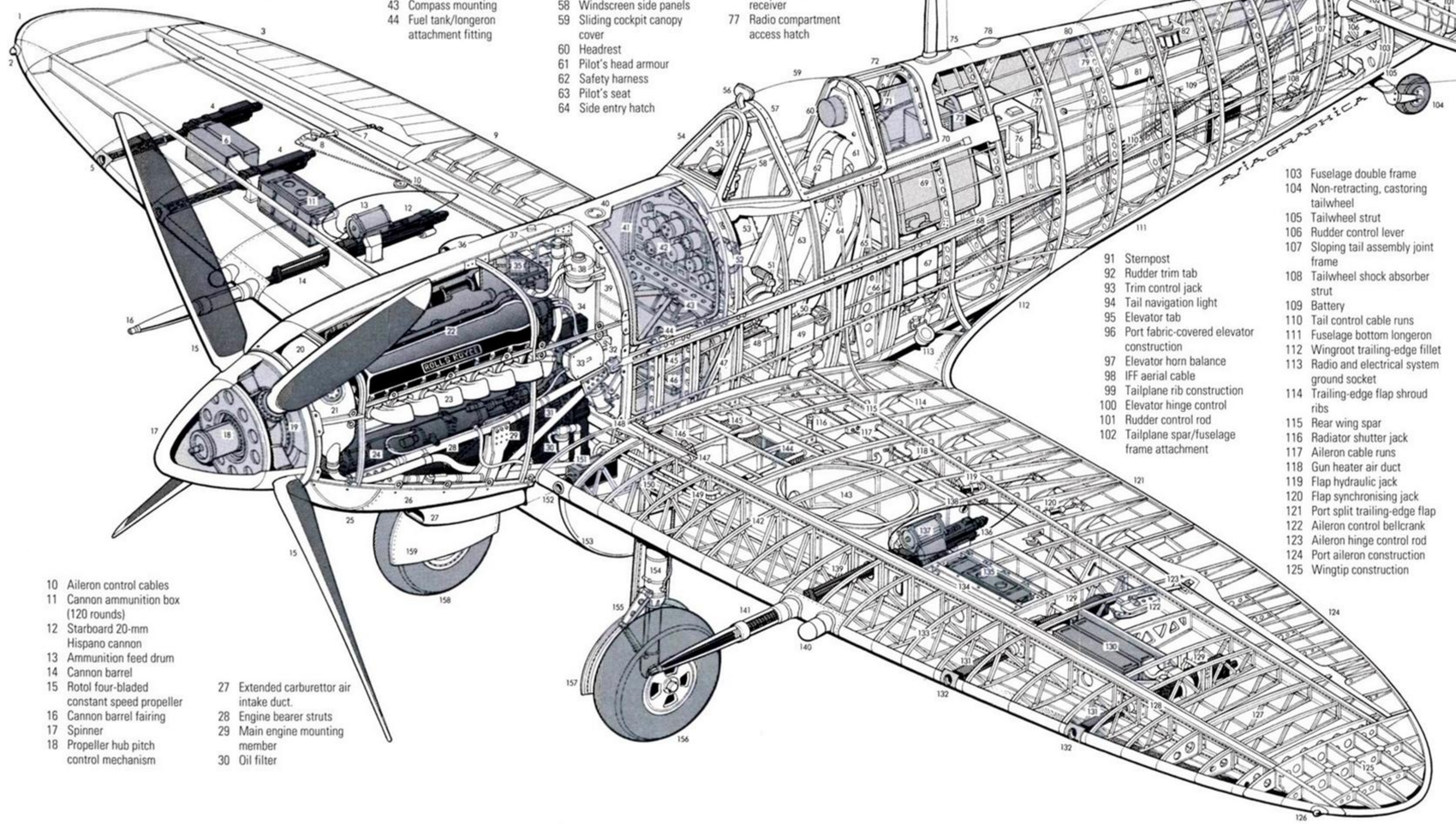


Left: Spitfires of Mks I, II and V shared a common cockpit. This example, equipped to a later standard than that above, has a new gun button and rudder pedals, the latter feature intended to improve rudder control during combat manoeuvres. The lever at the bottom of the picture controls the radiator intake flap.

Right: This is the right-hand side of the Spitfire cockpit illustrated above. Compared to those who flew the Messerschmitt Bf 109, the Spitfire's pilots enjoyed a relatively spacious cockpit. This was important during combat, for the pilots of these aircraft had enough space to apply more leverage to the control column during manoeuvres. By contrast, Bf 109 pilots had limited 'elbow room' in which to move.



Spitfire F.Mk IXC cutaway



1 Starboard wingtip
2 Navigation light
3 Starboard aileron
4 Browning 0.303-in (7.7-mm) machine-guns
5 Machine-gun ports (patched)
6 Ammunition boxes (350 rounds per gun)
7 Aileron control rod
8 Bellcrank hinge control
9 Starboard split trailing-edge flap
10 Aileron control cables
11 Cannon ammunition box (120 rounds)
12 Starboard 20-mm Hispano cannon
13 Ammunition feed drum
14 Cannon barrel
15 Rotol four-bladed constant speed propeller
16 Cannon barrel fairing
17 Spinner
18 Propeller hub pitch control mechanism
19 Armoured spinner backplate
20 Coolant system header tank
21 Coolant filler cap
22 Rolls-Royce Merlin 61 liquid-cooled Vee 12-cylinder-engine
23 Exhaust stubs
24 Forward engine mounting
25 Engine bottom cowling
26 Cowling integral oil tank, 5.6-Imp gal (25-litre) capacity
27 Extended carburettor air intake duct.
28 Engine bearer struts
29 Main engine mounting member
30 Oil filter
31 Two-stage supercharger
32 Engine bearer attachment
33 Suppressor
34 Engine accessories
35 Intercooler
36 Compressor air intake scoop
37 Hydraulic reservoir
38 Hydraulic system filter
39 Armoured firewall/fuel tank bulkhead
40 Fuel filler cap
41 Top main fuel tank, 48-Imp gal (218-litre) capacity
42 Back of instrument panel
43 Compass mounting
44 Fuel tank/longeron attachment fitting
45 Bottom main fuel tank, 37-Imp gal (168-litre) capacity
46 Rudder pedal bar
47 Sloping fuel tank bulkhead
48 Fuel cock control
49 Chart case
50 Trim control handwheel
51 Engine throttle and propeller controls
52 Control column handgrip
53 Radio controller
54 Bulletproof windscreen
55 Reflector gunsight
56 Pilot's rear view mirror
57 Canopy framing
58 Windscreen side panels
59 Sliding cockpit canopy cover
60 Headrest
61 Pilot's head armour
62 Safety harness
63 Pilot's seat
64 Side entry hatch
65 Back armour
66 Seat support frame
67 Pneumatic system air bottles
68 Fuselage main longeron
69 Auxiliary fuel tank, 29-Imp gal (132-litre) capacity, used only in conjunction with very-long-range slipper tank
70 Sliding canopy rail
71 Voltage regulator
72 Cockpit aft glazing
73 IFF radio equipment
74 HF aerial mast
75 Aerial cable lead-in
76 Radio transmitter/receiver
77 Radio compartment access hatch
78 Upper identification light
79 Rear fuselage frame construction
80 Fuselage skin plating
81 Oxygen bottle
82 Signal cartridge launcher
83 IFF aerial
84 Starboard tailplane
85 Starboard elevator
86 Fin front spar (fuselage frame extension)
87 Fin rib construction
88 HF aerial cable
89 Rudder mass balance
90 Rudder construction
91 Sternpost
92 Rudder trim tab
93 Trim control jack
94 Tail navigation light
95 Elevator tab
96 Port fabric-covered elevator construction
97 Elevator horn balance
98 IFF aerial cable
99 Tailplane rib construction
100 Elevator hinge control
101 Rudder control rod
102 Tailplane spar/fuselage frame attachment
103 Fuselage double frame
104 Non-retracting, castoring tailwheel
105 Tailwheel strut
106 Rudder control lever
107 Sloping tail assembly joint frame
108 Tailwheel shock absorber strut
109 Battery
110 Tail control cable runs
111 Fuselage bottom longeron
112 Wingroot trailing-edge fillet
113 Radio and electrical system ground socket
114 Trailing-edge flap shroud ribs
115 Rear wing spar
116 Radiator shutter jack
117 Aileron cable runs
118 Gun heater air duct
119 Flap hydraulic jack
120 Flap synchronising jack
121 Port split trailing-edge flap
122 Aileron control bellcrank
123 Aileron hinge control rod
124 Port aileron construction
125 Wingtip construction
126 Port navigation light
127 Wing lattice rib construction
128 Front spar
129 Browning 0.303-in (7.7-mm) machine-guns
130 Ammunition boxes (350 rounds per gun)
131 Machine-gun muzzle blast tubes
132 Machine-gun ports (patched)
133 Leading-edge nose ribs
134 Ammunition box armour protection
135 Cannon ammunition box (120 rounds)
136 Port 20-mm Hispano cannon
137 Ammunition feed drum
138 Cannon wing fairing
139 Cannon barrel
140 'C'-wing outboard cannon muzzle fairing (blanked-off)
141 Recoil spring
142 Inboard leading-edge lattice ribs
143 Main undercarriage wheel well
144 Oil radiator
145 Coolant radiator
146 Main undercarriage hydraulic jack
147 Retraction link
148 Wing spar/fuselage attachment joint
149 Oil pipe runs to radiator
150 Main undercarriage leg pivot fixing
151 Gun camera
152 Camera port
153 90-Imp gal (409-litre) jettisonable slipper tank
154 Mainwheel leg shock absorber
155 Undercarriage torque links
156 Port mainwheel
157 Mainwheel fairing door
158 Starboard mainwheel
159 Starboard wheel fairing door

Mk V production
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From fighter to 'Spitbomber'
From the earliest days of the Spitfire's career, the lack of hitting power of its eight rifle-calibre Browning machine-guns (in what later became known as the 'A' wing) had been a cause for concern. It was remedied by the installation of two Hispano 20-mm cannon with four Browning 0.303-in (7.7-mm) machine-guns. This armament fit (known as the 'B' configuration) was trialled in a small number of Spitfire Mk Is during the later stages of the Battle of Britain and, after major teething problems were solved, became the standard armament on early production Mk Vs.

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Most LF.Mk VBs as well as a number of F.Mk VBs and F.Mk VCs were delivered to the Middle East with clipped wings, which reduced the aircraft's span by 4 ft 8 in (1.42 m). Many other Spitfires were modified in-theatre by No. 103 MU at Aboukir. These latter aircraft featured wooden wingtip fairings, which were of a slightly more rounded shape than the standard metal examples fitted in the UK.

Engine and propeller
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Supermarine Spitfire F.Mk VC
No. 2 Squadron, No. 7 Wing, South African Air Force, Desert Air Force
Italy, late 1943/early 1944

Tropical modifications
In order to cope with the harsh conditions of the Western Desert and tropical regions, a number of modifications were made to Spitfires destined for overseas theatres. Proving trials took place during January 1942, most Mk VCs being so-equipped on the production line and a large number of Mk VBs being retrofitted. On the line, these 'tropicalised' aircraft were distinguished by the large Vokes Aero-Vee filter under the chin, but this concealed more than 20 other modifications, all covered by the RAF technical order known as Mod 411. They included fitting a larger oil tank, the addition of attachment points for three types of external fuel tank, provision of a desert survival kit (including a 1.5-Imp gal/6.8-litre water tank, an emergency tool kit and rations) and repainting the aircraft in appropriate camouflage. However, the Vokes filter seriously reduced the Spitfire Mk V's climb and speed performance. A comparison with a standard Mk VB showed an increase in time to 20,000 ft (6096 m) of 1 minute 24 seconds and a top speed at that altitude reduced by 11 mph (18 km/h). To reduce drag and thus address the speed problem, No. 103 Maintenance Unit at Aboukir, Egypt designed the new, more compact Aboukir filter, which was also lighter, offered improved filtration and could be used in temperate climates (with the filter element removed). They were retrofitted to numerous Mk Vs in the North African/Mediterranean theatre. It also served as the basis for the Vokes filter fitted later as standard to the Spitfire Mk VIII and to Mk IXs serving in the Mediterranean.

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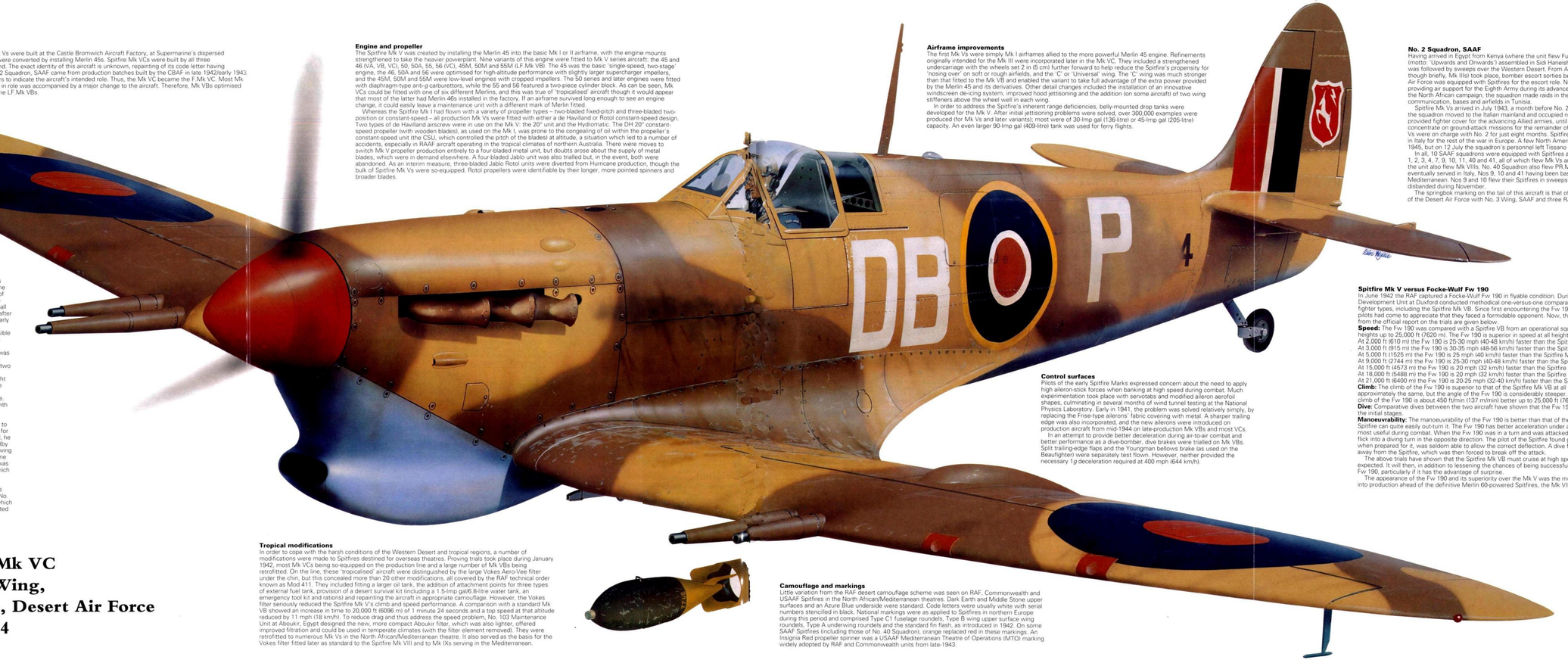

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Airframe improvements

The first Mk Vs were simply Mk I airframes allied to the more powerful Merlin 45 engine. Refinements originally intended for the Mk III were incorporated later in the Mk VC. They included a strengthened undercarriage with the wheels set 2 in (5 cm) further forward to help reduce the Spitfire's propensity for 'nosing over' on soft or rough airfields, and the 'C' or 'Universal' wing. The 'C' wing was much stronger than that fitted to the Mk VB and enabled the variant to take full advantage of the extra power provided by the Merlin 45 and its derivatives. Other detail changes included the installation of an innovative windscreen de-icing system, improved hood jettisoning and the addition (on some aircraft) of two wing stiffeners above the wheel well in each wing.

In order to address the Spitfire's inherent range deficiencies, belly-mounted drop tanks were developed for the Mk V. After initial jettisoning problems were solved, over 300,000 examples were produced (for Mk Vs and later variants); most were of 30-Imp gal (136-litre) or 45-Imp gal (205-litre) capacity. An even larger 90-Imp gal (409-litre) tank was used for ferry flights.

Control surfaces

Pilots of the early Spitfire Marks expressed concern about the need to apply high aileron-stick forces when banking at high speed during combat. Much experimentation took place with servotabs and modified aileron aerofoil shapes, culminating in several months of wind tunnel testing at the National Physics Laboratory. Early in 1941, the problem was solved relatively simply, by replacing the Frise-type ailerons' fabric covering with metal. A sharper trailing edge was also incorporated, and the new ailerons were introduced on production aircraft from mid-1944 on late-production Mk VBs and most VCs.

In an attempt to provide better deceleration during air-to-air combat and better performance as a dive-bomber, dive brakes were trialled on Mk VBs. Split trailing-edge flaps and the Youngman bellows brake (as used on the Beaufighter) were separately test flown. However, neither provided the necessary 1*g* deceleration required at 400 mph (644 km/h).

Camouflage and markings

Little variation from the RAF desert camouflage scheme was seen on RAF, Commonwealth and USAAF Spitfires in the North African/Mediterranean theatres. Dark Earth and Middle Stone upper surfaces and an Azure Blue underside were standard. Code letters were usually white with serial numbers stencilled in black. National markings were as applied to Spitfires in northern Europe during this period and comprised Type C1 fuselage roundels, Type B wing upper surface wing roundels, Type A underwing roundels and the standard fin flash, as introduced in 1942. On some SAAF Spitfires (including those of No. 40 Squadron), orange replaced red in these markings. An Insignia Red propeller spinner was a USAAF Mediterranean Theatre of Operations (MTO) marking widely adopted by RAF and Commonwealth units from late-1943.

No. 2 Squadron, SAAF

Having arrived in Egypt from Kenya (where the unit flew Furies, Gladiators and Hurricanes), No. 2 Squadron (motto: 'Upwards and Onwards') assembled in Sidi Haneish in July 1941. Training on Curtiss Tomahawk Mk IIBs was followed by sweeps over the Western Desert. From April 1942 conversion to Kittyhawks (Mk Is and later, though briefly, Mk IIIs) took place, bomber escort sorties being added to the squadron's duties until the Desert Air Force was equipped with Spitfires for the escort role. No. 2 thus concentrated on ground-attack work, providing air support for the Eighth Army during its advance through Libya after El Alamein. In the final months of the North African campaign, the squadron made raids in the battle area and attacked Axis lines of communication, bases and airfields in Tunisia.

Spitfire Mk Vs arrived in July 1943, a month before No. 2 moved to Sicily. Operational again from 23 August, the squadron moved to the Italian mainland and occupied newly-captured airfields during September. Spitfires provided fighter cover for the advancing Allied armies, until the lack of enemy air activity allowed them to concentrate on ground-attack missions for the remainder of the war. Though flown intensively, the Spitfire Mk Vs were on charge with No. 2 for just eight months. Spitfire Mk IXs arrived in February 1944, the unit remaining in Italy for the rest of the war in Europe. A few North American Mustang Mk IVs were taken 'on charge' in June 1945, but on 12 July the squadron's personnel left Tissano airfield en route for South Africa.

In all, 10 SAAF squadrons were equipped with Spitfires at one time or another during the war. They were Nos 1, 2, 3, 4, 7, 9, 10, 11, 40 and 41, all of which flew Mk Vs and IXs, though No. 1's use of Mk IXs was brief and the unit also flew Mk VIIIs. No. 40 Squadron also flew PR Mk XIs briefly towards the end of the war. Almost all eventually served in Italy, Nos 9, 10 and 41 having been based exclusively in North Africa and the Eastern Mediterranean. Nos 9 and 10 flew their Spitfires in sweeps over Crete in December 1944, No. 41 having disbanded during November.

The springbok marking on the tail of this aircraft is that of No. 7 Wing, SAAF which, by mid-1944, formed part of the Desert Air Force with No. 3 Wing, SAAF and three RAF wings.

Spitfire Mk V versus Focke-Wulf Fw 190

In June 1942 the RAF captured a Focke-Wulf Fw 190 in flyable condition. During the weeks that followed the Air Fighting Development Unit at Duxford conducted methodical one-versus-one comparative flight trials against each of the available Allied fighter types, including the Spitfire Mk VB. Since first encountering the Fw 190 in action 10 months earlier, Fighter Command's pilots had come to appreciate that they faced a formidable opponent. Now, the trials revealed just how formidable it was. Excerpts from the official report on the trials are given below.

Speed: The Fw 190 was compared with a Spitfire VB from an operational squadron for speed and all-round manoeuvrability at heights up to 25,000 ft (7620 m). The Fw 190 is superior in speed at all heights, and the approximate differences are as follows: At 2,000 ft (610 m) the Fw 190 is 25-30 mph (40-48 km/h) faster than the Spitfire Mk VB.
At 3,000 ft (915 m) the Fw 190 is 30-35 mph (48-56 km/h) faster than the Spitfire Mk VB.
At 5,000 ft (1525 m) the Fw 190 is 25 mph (40 km/h) faster than the Spitfire Mk VB.
At 9,000 ft (2744 m) the Fw 190 is 25-30 mph (40-48 km/h) faster than the Spitfire Mk VB.
At 15,000 ft (4573 m) the Fw 190 is 20 mph (32 km/h) faster than the Spitfire Mk VB.
At 18,000 ft (5488 m) the Fw 190 is 20 mph (32 km/h) faster than the Spitfire Mk VB.
At 21,000 ft (6400 m) the Fw 190 is 20-25 mph (32-40 km/h) faster than the Spitfire Mk VB.
Climb: The climb of the Fw 190 is superior to that of the Spitfire Mk VB at all heights. The best speeds for climbing are approximately the same, but the angle of the Fw 190 is considerably steeper. Under maximum continuous climbing conditions, the climb of the Fw 190 is about 450 ft/min (137 m/min) better up to 25,000 ft (7620 m).
Dive: Comparative dives between the two aircraft have shown that the Fw 190 can leave the Spitfire with ease, particularly during the initial stages.
Manoeuvrability: The manoeuvrability of the Fw 190 is better than that of the Spitfire Mk VB except in turning circles, when the Spitfire can quite easily out-turn it. The Fw 190 has better acceleration under all conditions of flight and this must obviously be most useful during combat. When the Fw 190 was in a turn and was attacked by the Spitfire, the superior rate of roll enabled it to flick into a diving turn in the opposite direction. The pilot of the Spitfire found great difficulty in following this manoeuvre, and, even when prepared for it, was seldom able to allow the correct deflection. A dive from this manoeuvre enabled the Fw 190 to draw away from the Spitfire, which was then forced to break off the attack.

The above trials have shown that the Spitfire Mk VB must cruise at high speed when in an area where enemy fighters can be expected. It will then, in addition to lessening the chances of being successfully 'bounced', have a better chance of catching the Fw 190, particularly if it has the advantage of surprise.

The appearance of the Fw 190 and its superiority over the Mk V was the most important factor in the decision to put the Mk IX into production ahead of the definitive Merlin 60-powered Spitfires, the Mk VII and Mk VIII.

Engine and propeller
The Spitfire Mk V was created by installing the Merlin 45 into the basic Mk I or II airframe, with the engine mounts strengthened to take the heavier powerplant. Nine variants of this engine were fitted to Mk V series aircraft: the 45 and 46 (VA, VB, VC), 50, 50A, 55, 56 (VC), 45M, 50M and 55M (LF.Mk VB). The 45 was the basic 'single-speed, two-stage' engine, the 46, 50A and 56 were optimised for high-altitude performance with slightly larger supercharger impellers, and the 45M, 50M and 55M were low-level engines with cropped impellers. The 50 series and later engines were fitted with diaphragm-type anti-*g* carburettors, while the 55 and 56 featured a two-piece cylinder block. As can be seen, Mk VCs could be fitted with one of six different Merlins, and this was true of 'tropicalised' aircraft though it would appear that most of the latter had Merlin 46s installed in the factory. If an airframe survived long enough to see an engine change, it could easily leave a maintenance unit with a different mark of Merlin fitted.

Whereas the Spitfire Mk I had flown with a variety of propeller types – two-bladed fixed-pitch and three-bladed two-position or constant-speed – all production Mk Vs were fitted with either a de Havilland or Rotol constant-speed design. Two types of de Havilland airscrew were in use on the Mk V: the 20° unit and the Hydromatic. The DH 20° constant-speed propeller (with wooden blades), as used on the Mk I, was prone to the congealing of oil within the propeller's constant-speed unit (the CSU, which controlled the pitch of the blades) at altitude, a situation which led to a number of accidents, especially in RAAF aircraft operating in the tropical climates of northern Australia. There were moves to switch Mk V propeller production entirely to a four-bladed metal unit, but doubts arose about the supply of metal blades, which were in demand elsewhere. A four-bladed Jablo unit was also trialled but, in the event, both were abandoned. As an interim measure, three-bladed Jablo Rotol units were diverted from Hurricane production, though the bulk of Spitfire Mk Vs were so-equipped. Rotol propellers were identifiable by their longer, more pointed spinners and broader blades.

Airframe improvements
The first Mk Vs were simply Mk I airframes allied to the mo
originally intended for the Mk III were incorporated later in t
undercarriage with the wheels set 2 in (5 cm) further forwar
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sh conditions of the Western Desert and tropical regions, a number of Spitfires destined for overseas theatres. Proving trials took place during January -equipped on the production line and a large number of Mk VBs being 'tropicalised' aircraft were distinguished by the large Vokes Aero-Vee filter ealed more than 20 other modifications, all covered by the RAF technical order luded fitting a larger oil tank, the addition of attachment points for three types n of a desert survival kit (including a 1.5-Imp gal/6.8-litre water tank, an s) and repainting the aircraft in appropriate camouflage. However, the Vokes itfire Mk V's climb and speed performance. A comparison with a standard Mk ne to 20,000 ft (6096 m) of 1 minute 24 seconds and a top speed at that altitude . To reduce drag and thus address the speed problem, No. 103 Maintenance ed the new, more compact Aboukir filter, which was also lighter, offered be used in temperate climates (with the filter element removed). They were s in the North African/Mediterranean theatre. It also served as the basis for the ndard to the Spitfire Mk VIII and to Mk IXs serving in the Mediterranean.

Camouflage and markings
Little variation from the RAF desert camouflage scheme was seen on RAF, Commonwealth and USAAF Spitfires in the North African/Mediterranean theatres. Dark Earth and Middle Stone upper surfaces and an Azure Blue underside were standard. Code letters were usually white with serial numbers stencilled in black. National markings were as applied to Spitfires in northern Europe during this period and comprised Type C1 fuselage roundels, Type B wing upper surface wing roundels, Type A underwing roundels and the standard fin flash, as introduced in 1942. On some SAAF Spitfires (including those of No. 40 Squadron), orange replaced red in these markings. An Insignia Red propeller spinner was a USAAF Mediterranean Theatre of Operations (MTO) marking widely adopted by RAF and Commonwealth units from late-1943.

Airframe improvements
The first Mk Vs were simply Mk I airframes allied to the more powerful Merlin 45 engine. Refinements originally intended for the Mk III were incorporated later in the Mk VC. They included a strengthened undercarriage with the wheels set 2 in (5 cm) further forward to help reduce the Spitfire's propensity for 'nosing over' on soft or rough airfields, and the 'C' or 'Universal' wing. The 'C' wing was much stronger than that fitted to the Mk VB and enabled the variant to take full advantage of the extra power provided by the Merlin 45 and its derivatives. Other detail changes included the installation of an innovative windscreen de-icing system, improved hood jettisoning and the addition (on some aircraft) of two wing stiffeners above the wheel well in each wing.

In order to address the Spitfire's inherent range deficiencies, belly-mounted drop tanks were developed for the Mk V. After initial jettisoning problems were solved, over 300,000 examples were produced (for Mk Vs and later variants); most were of 30-Imp gal (136-litre) or 45-Imp gal (205-litre) capacity. An even larger 90-Imp gal (409-litre) tank was used for ferry flights.

No. 2 Squadron, SAAF
Having arrived in Egypt from Kenya (where the unit flew Furies, Gladiators and Hurricanes), No. 2 Squadron (motto: 'Upwards and Onwards') assembled in Sidi Haneish in July 1941. Training on Curtiss Tomahawk Mk IIBs was followed by sweeps over the Western Desert. From April 1942 conversion to Kittyhawks (Mk Is and later, though briefly, Mk IIIs) took place, bomber escort sorties being added to the squadron's duties until the Desert Air Force was equipped with Spitfires for the escort role. No. 2 thus concentrated on ground-attack work, providing air support for the Eighth Army during its advance through Libya after El Alamein. In the final months of the North African campaign, the squadron made raids in the battle area and attacked Axis lines of communication, bases and airfields in Tunisia.

Spitfire Mk Vs arrived in July 1943, a month before No. 2 moved to Sicily. Operational again from 23 August, the squadron moved to the Italian mainland and occupied newly-captured airfields during September. Spitfires provided fighter cover for the advancing Allied armies, until the lack of enemy air activity allowed them to concentrate on ground-attack missions for the remainder of the war. Though flown intensively, the Spitfire Mk Vs were on charge with No. 2 for just eight months. Spitfire Mk IXs arrived in February 1944, the unit remaining in Italy for the rest of the war in Europe. A few North American Mustang Mk IVs were taken 'on charge' in June 1945, but on 12 July the squadron's personnel left Tissano airfield en route for South Africa.

In all, 10 SAAF squadrons were equipped with Spitfires at one time or another during the war. They were Nos 1, 2, 3, 4, 7, 9, 10, 11, 40 and 41, all of which flew Mk Vs and IXs, though No. 1's use of Mk IXs was brief and the unit also flew Mk VIIIs. No. 40 Squadron also flew PR.Mk XIs briefly towards the end of the war. Almost all eventually served in Italy, Nos 9, 10 and 41 having been based exclusively in North Africa and the Eastern Mediterranean. Nos 9 and 10 flew their Spitfires in sweeps over Crete in December 1944, No. 41 having disbanded during November.

The springbok marking on the tail of this aircraft is that of No. 7 Wing, SAAF which, by mid-1944, formed part of the Desert Air Force with No. 3 Wing, SAAF and three RAF wings.

Spitfire Mk V versus Focke-Wulf Fw 190
In June 1942 the RAF captured a Focke-Wulf Fw 190 in flyable condition. During the weeks that followed the Air Fighting Development Unit at Duxford conducted methodical one-versus-one comparative flight trials against each of the available Allied fighter types, including the Spitfire Mk VB. Since first encountering the Fw 190 in action 10 months earlier, Fighter Command's pilots had come to appreciate that they faced a formidable opponent. Now, the trials revealed just how formidable it was. Excerpts from the official report on the trials are given below.

Speed: The Fw 190 was compared with a Spitfire VB from an operational squadron for speed and all-round manoeuvrability at heights up to 25,000 ft (7620 m). The Fw 190 is superior in speed at all heights, and the approximate differences are as follows:
At 2,000 ft (610 m) the Fw 190 is 25-30 mph (40-48 km/h) faster than the Spitfire Mk VB.
At 3,000 ft (915 m) the Fw 190 is 30-35 mph (48-56 km/h) faster than the Spitfire Mk VB.
At 5,000 ft (1525 m) the Fw 190 is 25 mph (40 km/h) faster than the Spitfire Mk VB.
At 9,000 ft (2744 m) the Fw 190 is 25-30 mph (40-48 km/h) faster than the Spitfire Mk VB.
At 15,000 ft (4573 m) the Fw 190 is 20 mph (32 km/h) faster than the Spitfire Mk VB.
At 18,000 ft (5488 m) the Fw 190 is 20 mph (32 km/h) faster than the Spitfire Mk VB.
At 21,000 ft (6400 m) the Fw 190 is 20-25 mph (32-40 km/h) faster than the Spitfire Mk VB.

Climb: The climb of the Fw 190 is superior to that of the Spitfire Mk VB at all heights. The best speeds for climbing are approximately the same, but the angle of the Fw 190 is considerably steeper. Under maximum continuous climbing conditions, the climb of the Fw 190 is about 450 ft/min (137 m/min) better up to 25,000 ft (7620 m).

Dive: Comparative dives between the two aircraft have shown that the Fw 190 can leave the Spitfire with ease, particularly during the initial stages.

Manoeuvrability: The manoeuvrability of the Fw 190 is better than that of the Spitfire Mk VB except in turning circles, when the Spitfire can quite easily out-turn it. The Fw 190 has better acceleration under all conditions of flight and this must obviously be most useful during combat. When the Fw 190 was in a turn and was attacked by the Spitfire, the superior rate of roll enabled it to flick into a diving turn in the opposite direction. The pilot of the Spitfire found great difficulty in following this manoeuvre, and, even when prepared for it, was seldom able to allow the correct deflection. A dive from this manoeuvre enabled the Fw 190 to draw away from the Spitfire, which was then forced to break off the attack.

The above trials have shown that the Spitfire Mk VB must cruise at high speed when in an area where enemy fighters can be expected. It will then, in addition to lessening the chances of being successfully 'bounced', have a better chance of catching the Fw 190, particularly if it has the advantage of surprise.

The appearance of the Fw 190 and its superiority over the Mk V was the most important factor in the decision to put the Mk IX into production ahead of the definitive Merlin 60-powered Spitfires, the Mk VII and Mk VIII.

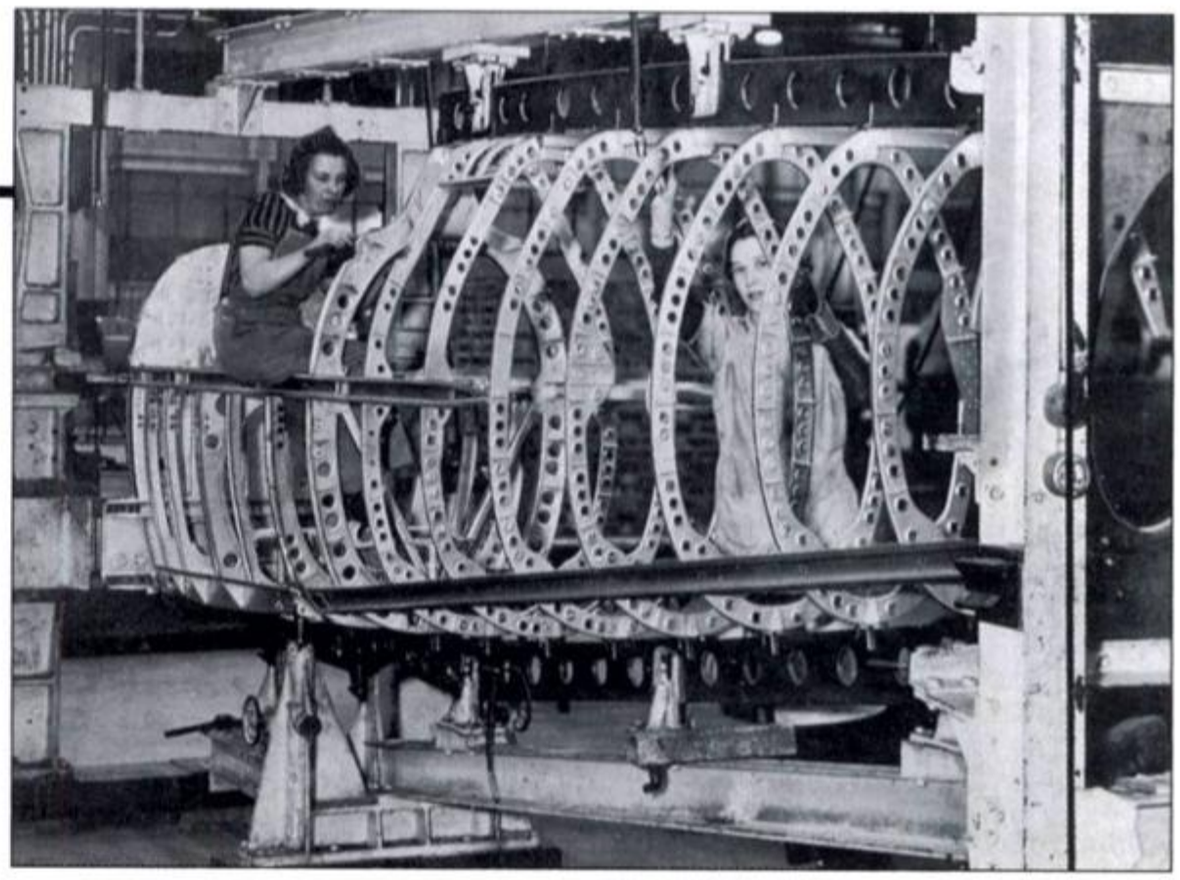
Control surfaces
Pilots of the early Spitfire Marks expressed concern about the need to apply high aileron-stick forces when banking at high speed during combat. Much experimentation took place with servotabs and modified aileron aerofoil shapes, culminating in several months of wind tunnel testing at the National Physics Laboratory. Early in 1941, the problem was solved relatively simply, by replacing the Frise-type ailerons' fabric covering with metal. A sharper trailing edge was also incorporated, and the new ailerons were introduced on production aircraft from mid-1944 on late-production Mk VBs and most VCs.

In an attempt to provide better deceleration during air-to-air combat and better performance as a dive-bomber, dive brakes were trialled on Mk VBs. Split trailing-edge flaps and the Youngman bellows brake (as used on the Beaufighter) were separately test flown. However, neither provided the necessary 1*g* deceleration required at 400 mph (644 km/h).

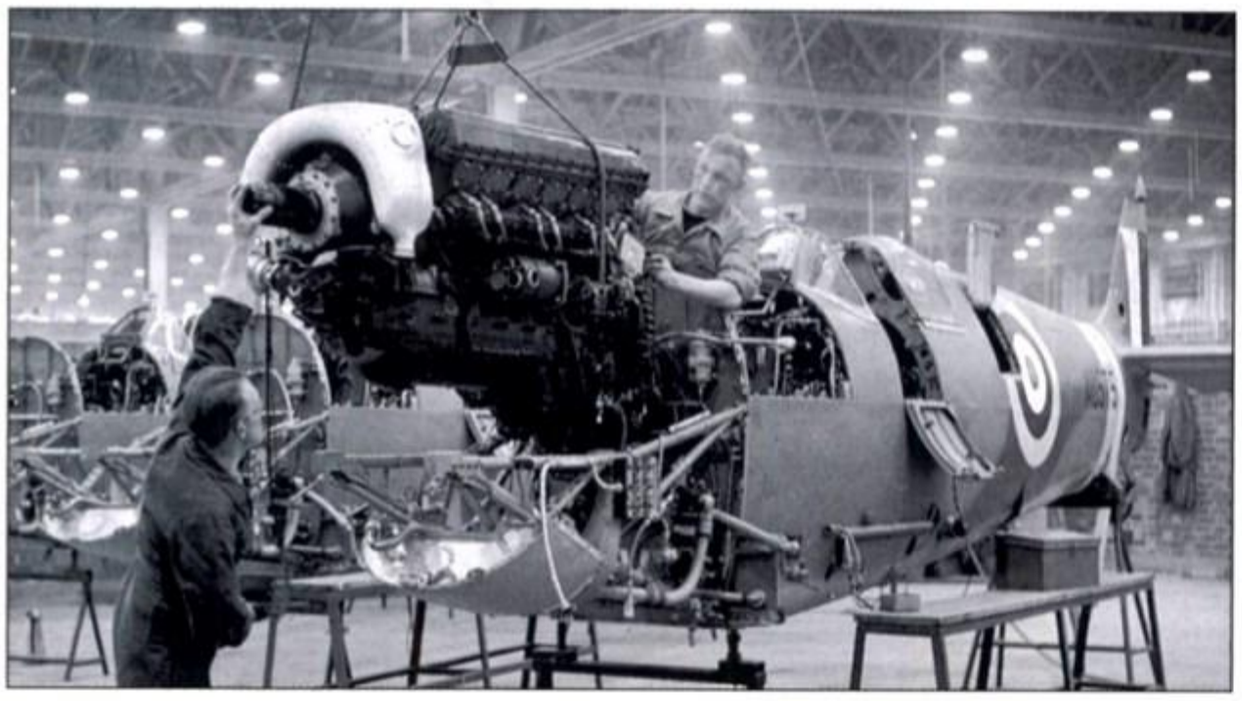
Camouflage and markings
Little variation from the RAF desert camouflage scheme was seen on RAF, Commonwealth and USAAF Spitfires in the North African/Mediterranean theatres. Dark Earth and Middle Stone upper surfaces and an Azure Blue underside were standard. Code letters were usually white with serial numbers stencilled in black. National markings were as applied to Spitfires in northern Europe during this period and comprised Type C1 fuselage roundels, Type B wing upper surface wing roundels, Type A underwing roundels and the standard fin flash, as introduced in 1942. On some SAAF Spitfires (including those of No. 40 Squadron), orange replaced red in these markings. An Insignia Red propeller spinner was a USAAF Mediterranean Theatre of Operations (MTO) marking widely adopted by RAF and Commonwealth units from late-1943.

Building the Spitfire

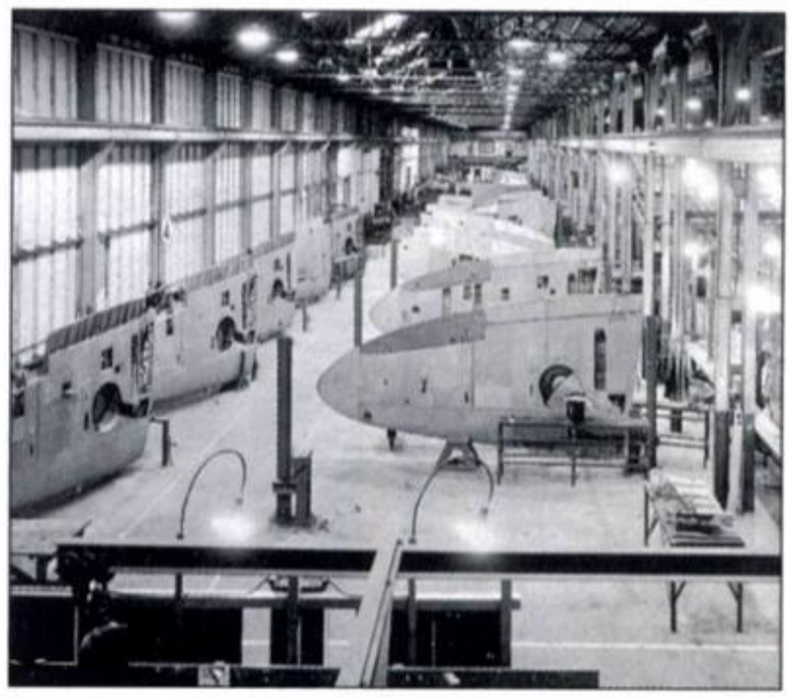
Left: Westland Aircraft built 685 Spitfire Mk Is and Vs, and was responsible for all Seafire development. Here, wing ribs are assembled in a fabrication shop at Sherborne.



Right: Two workers at the Castle Bromwich Aircraft Factory assemble a Spitfire fuselage.

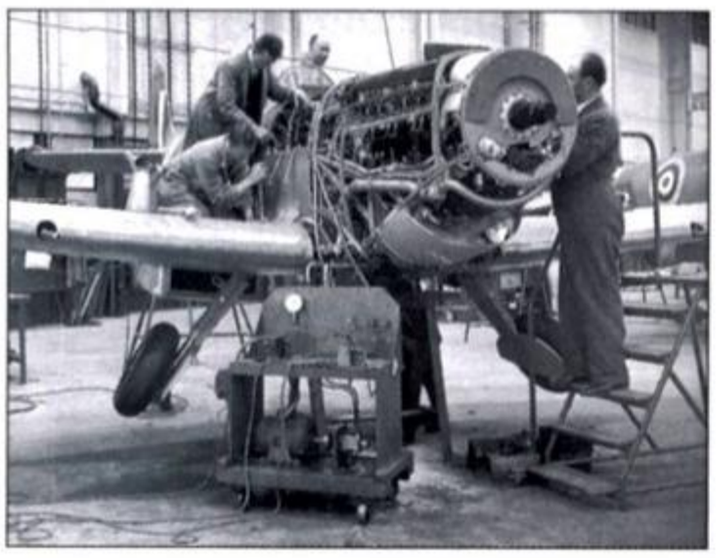


Left: Fitters at the CBAF introduce a Merlin 45 to its Mk V fuselage during final assembly. Below the front of the engine is its oil tank.

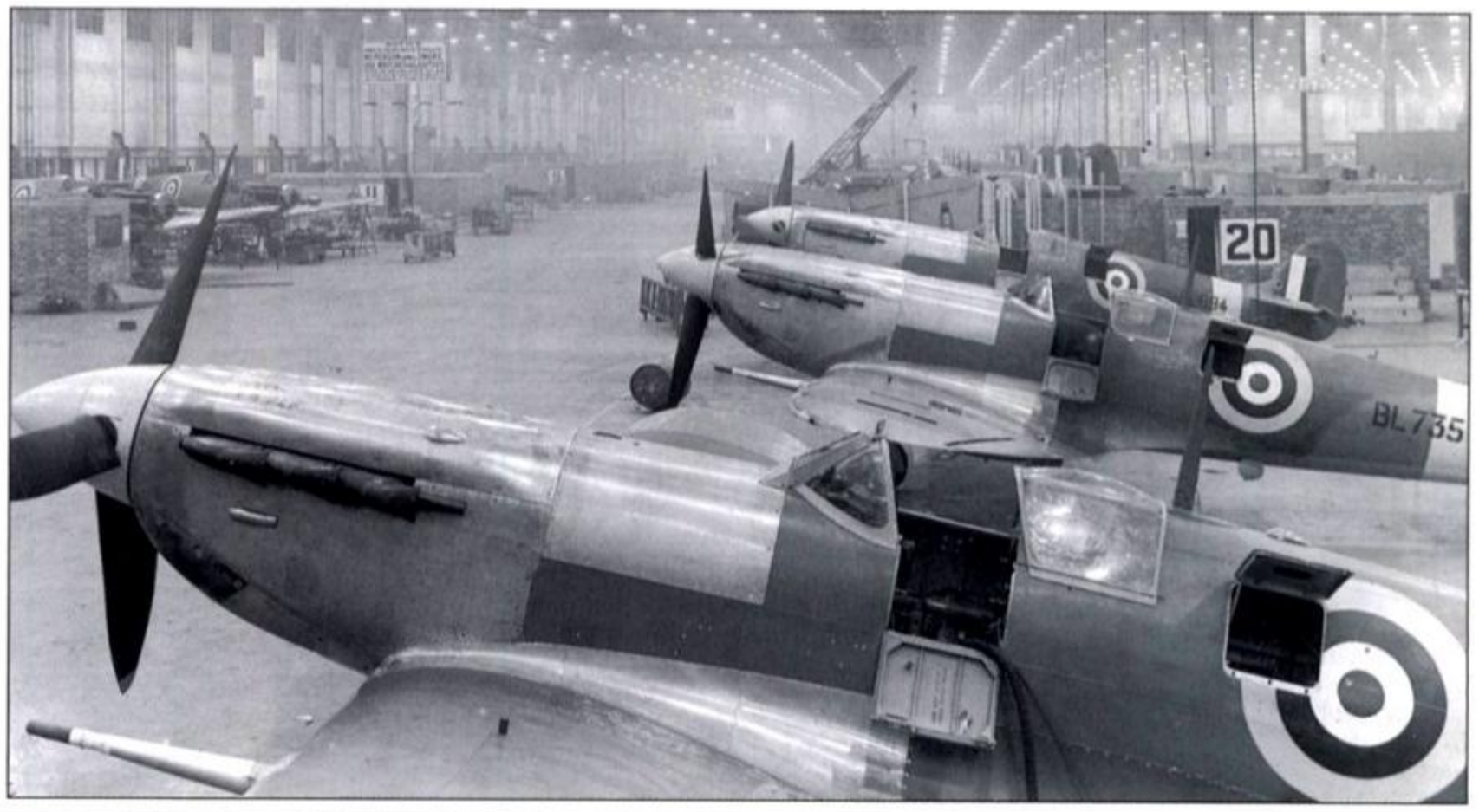


Right: Spitfire Mk VB wings undergo assembly at the Westland factory. The undercarriage is already installed so that it can be immediately lowered to support the airframe to which the wing will eventually be attached.

Below: This Mk VB is in the final stage of assembly. Engine cowlings and a propeller will be fitted, after which the hydraulics will be charged and the undercarriage lowered.

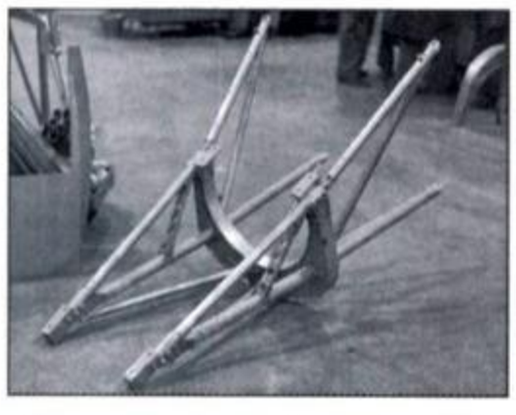


Right: Recently completed Rotol propeller-fitted Mk VBs await an air test after final assembly at Castle Bromwich in 1942. BL735 survived the war to be struck off in 1946; BL894 became a Seafire Mk IB in 1943.

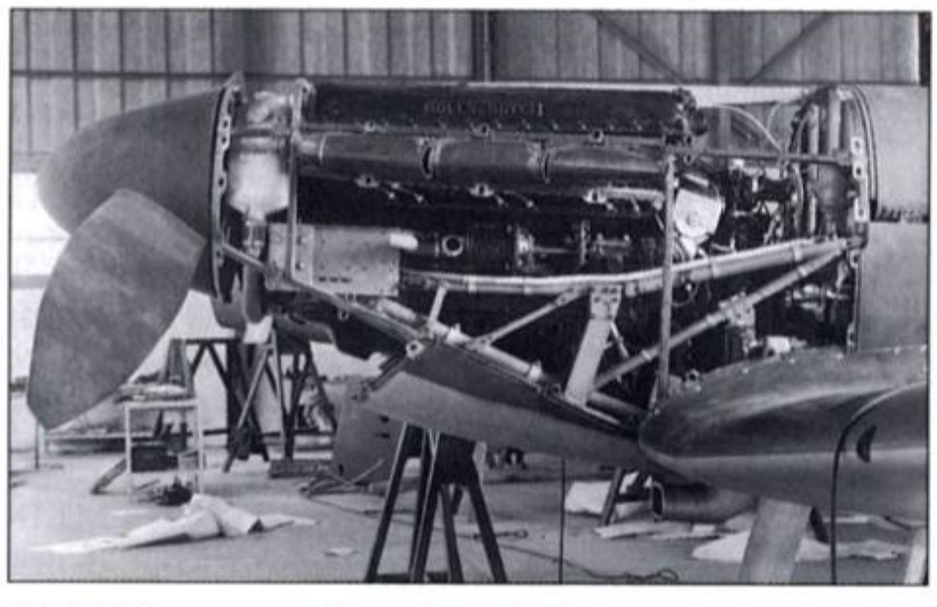


Engine installation

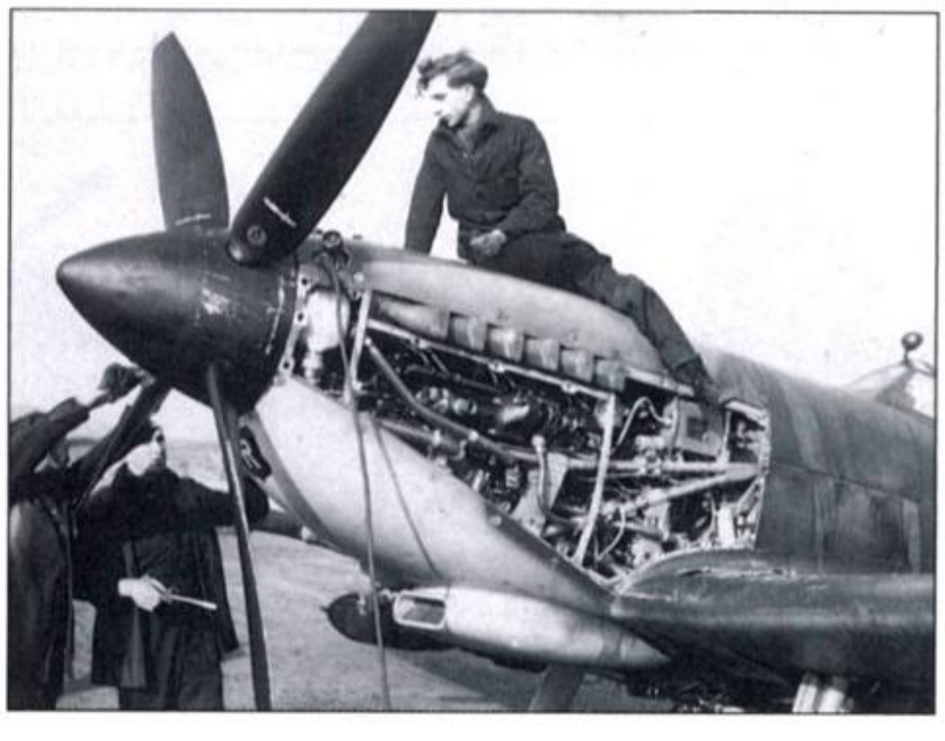
Right: This Merlin 45 installation in a Mk VA features a Rotol propeller.



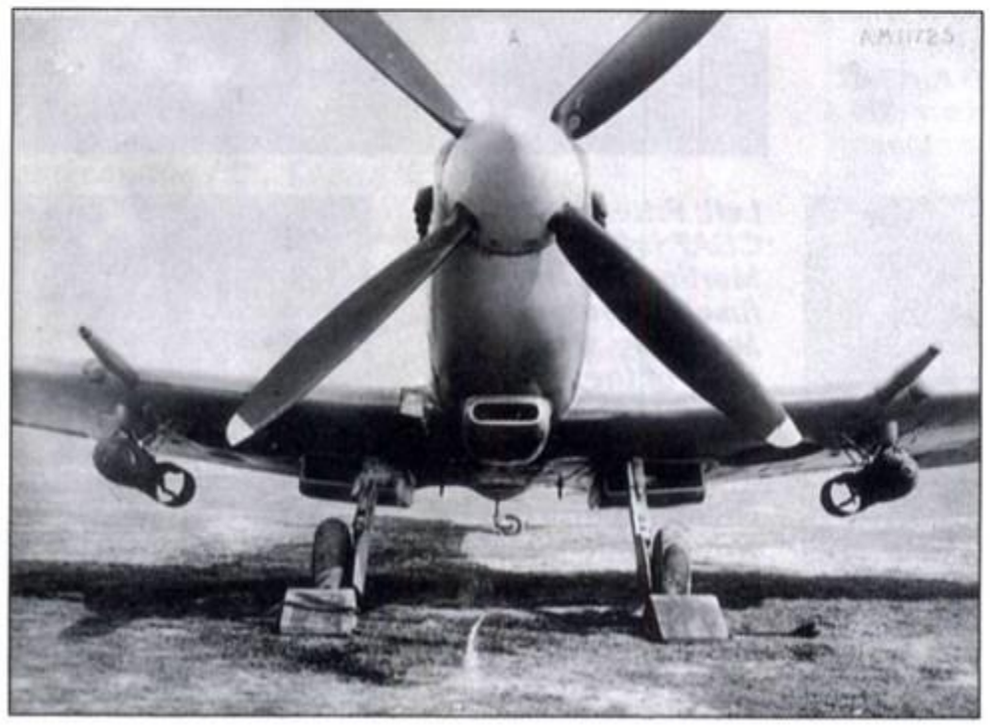
Above: The horseshoe-shaped cross-member was the key to the engine mount's strength.

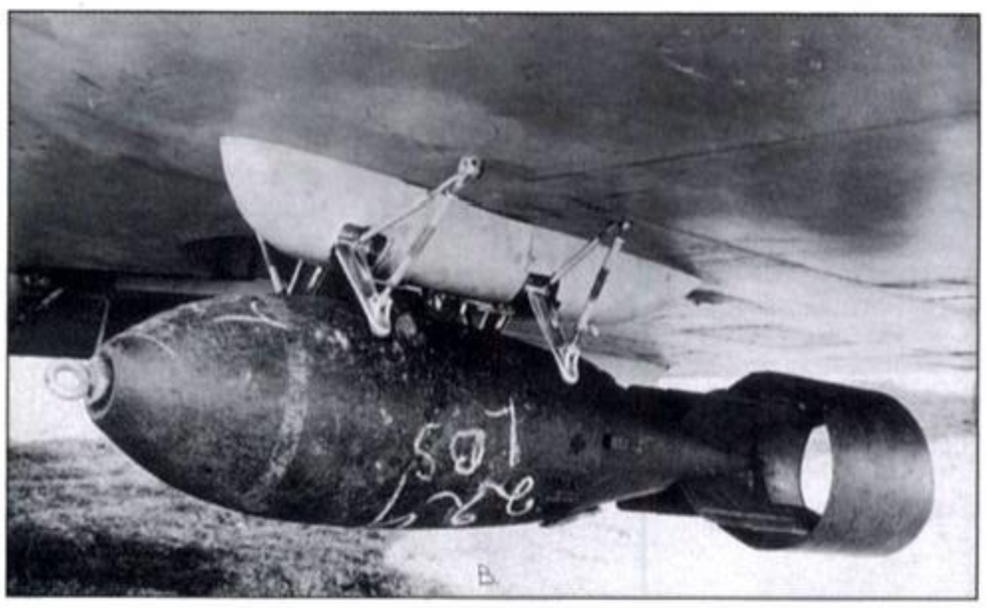


Right: The open cowling of a Mk XVIE reveals the Packard Merlin 266. The power of the Merlin 60 series necessitated the use of a four-bladed propeller.



Air-to-ground Spitfires





Above: The Mk V was the first Spitfire variant to be equipped for air-to-ground roles, as illustrated in this photograph of a Mk VB carrying a 250-lb (113-kg) bomb under each wing.

Right and below right: Underwing 250-lb (113-kg) bomb installations on a Mk IXC aircraft.

Above: This Spitfire Mk IX of No. 74 Squadron is fitted with a single launcher for a 60-lb (27-kg) rocket under each wing, of the type used by the RAF's Hawker Typhoons. This weapon was rather inaccurate, and most other fighter-bomber types ripple-fired eight or more to give a reasonable chance of hitting a small target. The two-rocket installation for the Spitfire appears to have been unique to this unit, and it saw little use.

cut off at Sinzweya to stand firm, and, relying on the Spitfires to maintain air superiority, transport planes supplied the outpost until it could be relieved. Nos 67, 81 and 152 Squadrons with Spitfire VIIIs moved to Ramu near the India/Burma border, from where they flew offensive patrols and escort missions. The airlift by heavily laden Dakota and Commando transport planes proceeded unhindered.

With the British and Commonwealth forces standing firm, it was the Japanese troops that now had problems. The latter had expected to live on food in the Allied stores they overran, but, supplied by air, the defenders held their ground and the food stores remained in their hands. Once the Japanese soldiers had eaten what they carried in their backpacks, they went hungry. Lacking any effective means of resupply, they attempted to survive on the meagre fare they found in the jungle. When that proved insufficient, the starving infiltrators abandoned their positions and began the trudge to their own territory. The siege of Sinzweya ended on 23 February.

Among a number of air-to-ground weapons trialled on Spitfires was this rocket installation, using four on zero-length launchers, seen here fitted to a Mk IXC.

Spitfires rule the skies

The success achieved at Sinzweya served as a pattern to defeat the main Japanese offensive in Burma, launched in March 1944. Again the attackers infiltrated through the jungle, to cut off 55,000 Allied troops at Kohima and Imphal. Again the garrisons stood firm, supplied by a large-scale airlift. And, again, starvation forced the attackers to break off the action and retreat. Throughout, the Spitfires ruled the skies and during the 80 days of the airlift only three transport planes were lost to enemy action. It was a major victory for the Allies, and the Spitfire VIIIs had made it possible.

The Royal Australian Air Force received a total of 410 Mk VIIIs, with the first of them arriving at Melbourne in October 1943. Five squadrons in the south Pacific area were equipped with this variant. In the summer of 1945 No. 80 Wing, RAAF, commanded by fighter ace Group Captain Clive Caldwell, moved to New Guinea. By this time Japanese air activity over the southwest Pacific area had virtually ended, however. With little opportunity for air-to-air combat, the wing engaged mainly in ground attack operations.

The Mk XVI was a Mk IX airframe fitted with the Merlin 266 engine, a Merlin 66 manufactured under licence by the US Packard company. Externally the Mks IX and XVI were identical in appearance, and they were little different in performance. The Packard engine was manufactured to

American measurements, however, and servicing tools and spare parts were not interchangeable between the Rolls-Royce and Packard engines. To prevent confusion, therefore, the Packard-engined version was designated the Mk XVI.

Mk XVIs started to come off the production line at Castle Bromwich in October 1944. At the beginning of December, No. 403 Squadron based at Evère near Brussels was the first unit to exchange its Mk IXs for Mk XVIs. Other Mk IX units in the 2nd Tactical Air Force quickly followed and when the war in Europe ended, a total of 19 squadrons had re-equipped with this variant.

Four major improvements to the Mk IX and the Mk XVI

The Spitfire Mks IX and XVI were the last Merlin-engined fighter variants in production. To improve their combat capabilities, both had four major improvements incorporated: the gyro gunsight, the fitting of the 'E'-type wing and armament, the fitting of the bubble canopy, and the installation of additional fuel tanks.

1. The gyro gunsight

No matter how fast, how manoeuvrable or how heavily armed a fighter was, those factors counted for little if only a small proportion of the rounds it fired hit their target. With the fixed-graticule GM2 reflector sight previously fitted to the Spitfire, the pilot had to judge the deflection angle when engaging a manoeuvring or crossing target. The ability to do this quickly and accurately was one of the main skills that separated the ace pilot from the also-ran.

After four years of development at the Royal Aircraft Establishment at Farnborough, the gyro gunsight Mk II went into large-scale production at the end of 1943. This sophisticated predictor sight calculated the correct point in

Late-war Spitfires

Above: Flaps down, a pair of Mk XVIEs of No. 74 Squadron is about to land at B.105/Droppe in western Germany after one of the unit's last missions of the war, in April 1945.

Left: Carrying a 45-Imp gal (204-litre) drop tank, this Mk XVIE of No. 403 Squadron, RCAF takes off from Soltau in Germany in July 1945. Though equipped with 'clipped' wings and the later-pattern broad-chord rudder, it is an early-build aircraft with the original-type cockpit.

Mk XVIs of 'B' Flight, No. 443 Squadron, RCAF are seen at Diepholz in April 1945. One of the last RCAF squadrons to be deployed to Europe, No. 443 flew its first sorties with No. 144 Wing just before D-Day. Mk XVIs replaced the unit's Mk IXs in January 1945.

'High back' Mk XVIEs of No. 74 Squadron are seen at their PSP (pierced steel planking) dispersal point at Schijndel in the spring of 1945.

Packard Merlin Spitfire

Spitfire LF.Mk XVIE
TB675 was one of No. 74 Squadron's Mk XVIs engaged in ground attack missions in the last days of the war in Europe. It exhibits most of the modifications made to Mk IX/XVI aircraft during production, including 'clipped' wings, a tropical filter, 'rear-view fuselage', broad-chord rudder and bomb racks.

Above: Three fighter squadrons, known collectively as the 'Eagle' squadrons, were manned by American volunteers before the US entered the war after Pearl Harbor. This Mk V carries the codes of No. 121 Squadron. With Nos 71 and 133 Squadrons, this unit became the 4th Fighter Group 'The Eagles', US 8th Air Force in September 1942.

Right: Spitfire Mk Vs of No. 401 Squadron, RCAF perform a flypast over Biggin Hill in September 1943. Of the foreign and Commonwealth countries that made personnel available to the RAF during the war, Canada contributed by far the largest number.

Above: Before being dispatched to Australia as part of the wing sent to defend the Dominion from Japanese attacks, No. 457 Squadron, RAAF operated Spitfire Mk I, II and V aircraft from bases in England between mid-1941 and mid-1942. In Australia it flew tropicalised Mk Vs and Mk VIIIs.

the sky ahead of the target, at which the pilot needed to aim his guns in order to score hits. It took time for pilots to learn the foibles of the new sight. However, once the average squadron pilot had done so, the accuracy of his deflection shooting improved dramatically. During 1944 an analysis of 130 combats by Spitfire IXs fitted with fixed-graticule sights showed there had been 34 kills – 26 per cent of the total. During the same period, a squadron operating the same variant with the new gunsight fought 38 combats and secured 19 kills – 50 per cent of the total. In other words, the use of the new gunsight had virtually doubled the effectiveness of a unit's air-to-air gunnery. With the new sight pilots, could hit evading targets at deflection angles of up to 50°, at ranges as great as 1,800 ft (548 m).

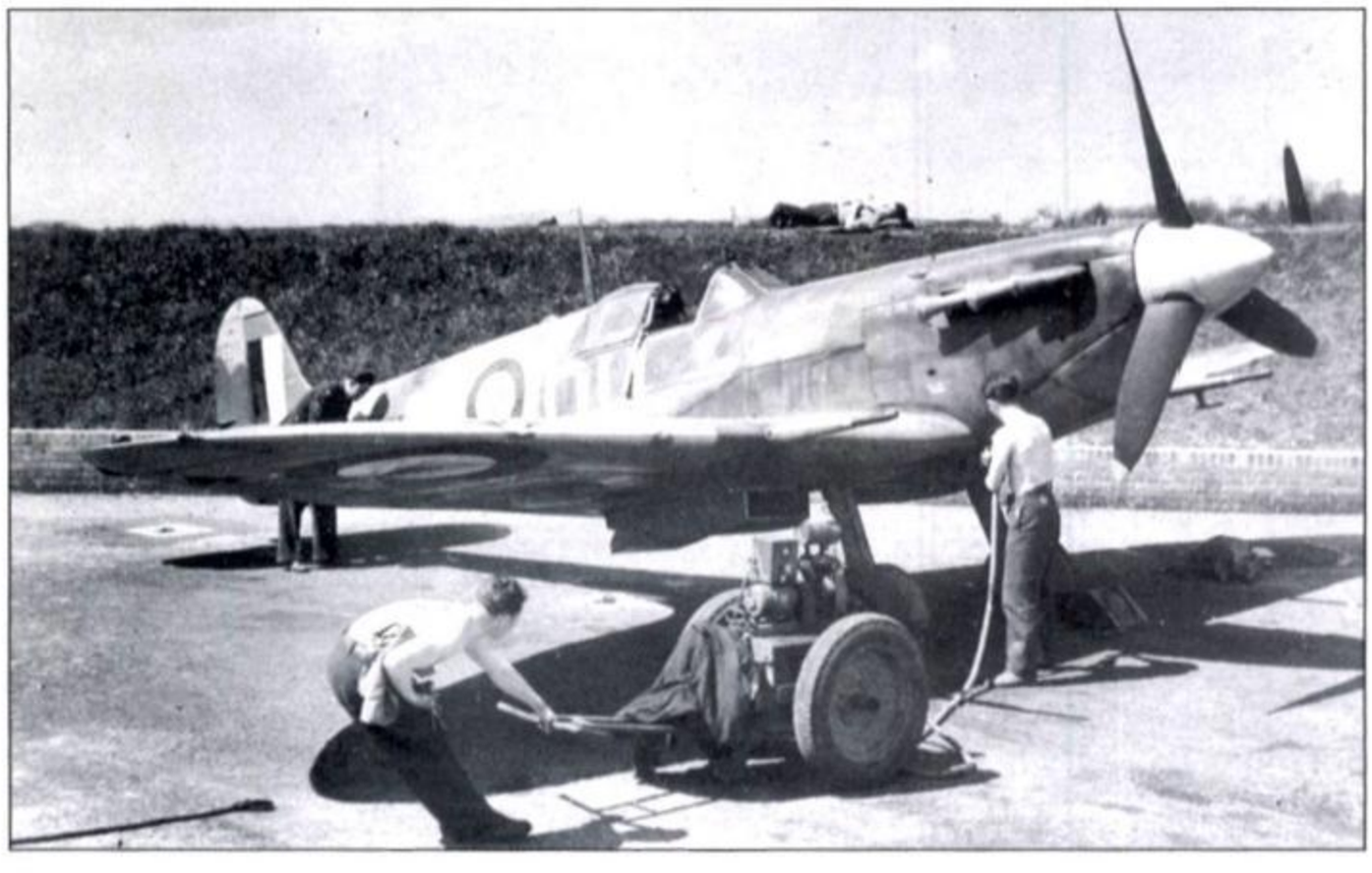
Many fighter aces refused to have the new gunsight in their aircraft, however. It was necessary to track the target for a few seconds while the mechanism calculated the deflection angle, and that was an unwanted inconvenience to those pilots who could judge the angle at a glance. For the rest of the Allied fighter force, however, the new gunsight brought a considerable and one-sided advantage in combat (the German equivalent, the EZ 42, came too late and saw little use in combat).

During the final months of the war, the Spitfire and other Allied piston-engined fighters had to battle with the much faster German jet types. The improvement in air-to-air gunnery brought about by the new sight helped compensate for their inferior performance, and assisted them to maintain air superiority in what might otherwise have been a difficult period.

2. 'E'-type wing and revised armament

From the spring of 1941 until the summer of 1944, the great majority of Spitfire fighter variants carried the standard armament of two 20-mm Hispano cannon and four 0.303-in Browning machine-guns. In air-to-air combat the four Browning machine-guns were of questionable value, however. By the latter stages of the war, nearly all combat aircraft had their vital areas armoured to protect them against hits with rifle-calibre rounds. Moreover, the Spitfire's 0.303-in weapons were mounted in the outer wings, which flexed when the pilot pulled *g*. When the machine-guns were fired under those conditions, the rounds went in a direction rather different from that in which the gunsight was pointing.

A Spitfire Mk VB of No. 312 (Czech) Squadron has the 'trolley acc' starter batteries plugged in, at its dispersal at Harrowbeer in the spring of 1942. No. 312 was one of two Czech RAF units to operate Spitfires, the other being No. 313 Squadron.

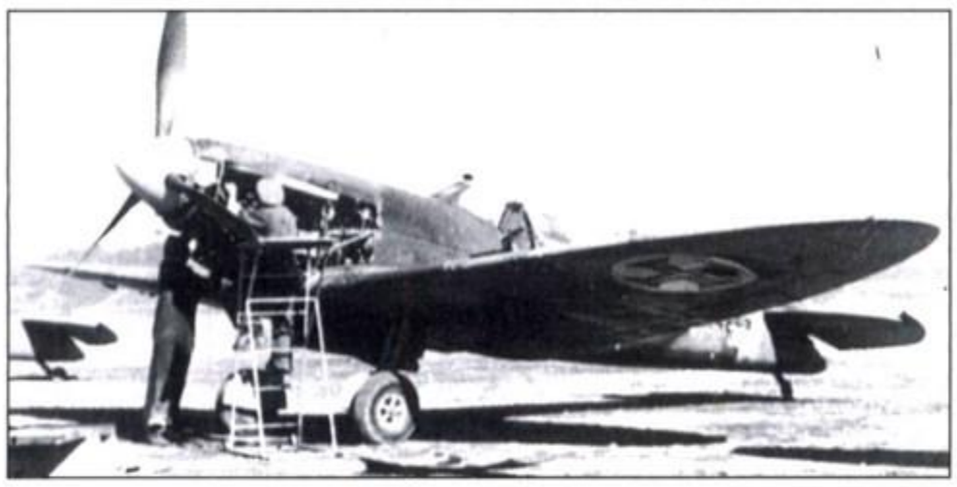


Above: A Mk VB of No. 302 (Polish) Squadron sports the four white nose stripes worn by many Spitfire units during the Dieppe landing operations of 19 August 1942. The aircraft was flown on that day by Wg Cdr Stefan Witorzenc, commanding the 1st Polish Fighter Wing.

Below: Coded '3W', this 'clipped'-wing aircraft was one of a number of Spitfires of Mks V, IX, XIV and XVI flown by Dutch pilots.

Neutral Spitfires

Neutral governments in Turkey, Portugal and Egypt were supplied with Spitfires at various stages during World War II, largely as a way of maintaining the favourable disposition of these states towards the Allies. Aircraft were supplied in large numbers to the Soviet Union.



This is one of the 18 by-then-surplus Spitfire Mk IAs supplied to Portugal in 1942 to equip a unit at Tancos Aerial Base, later transferred to Ota. The Azores Agreement, signed in 1943, was followed by the delivery of 33 ex-RAF Mk VBs to equip two more squadrons. Others were supplied after 1945.

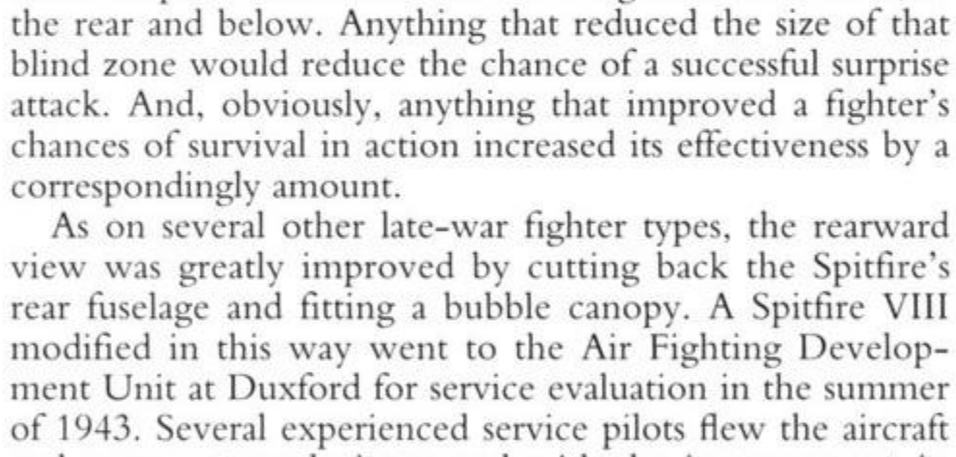
During 1944, the US Browning 0.5-in (12.7 mm) machine-gun became available to the RAF in quantity. The Spitfire's wings were redesigned to house two of these weapons and two 20-mm cannon, all of them in the stiffer inboard wing section. The two 20-mm weapons were moved to the outer cannon positions, while the 0.5-in machine-guns went into the spaces previously occupied by the inboard cannon. The 0.5-in weapon delivered a greater penetrative punch than the rifle-calibre weapons it replaced, and it was considerably more effective for both air-to-air and air-to-ground firing.

3. The bubble canopy

Most pilots shot down in fighter-versus-fighter combat never saw their assailant before their aircraft was hit. Most of the surprise attacks came from the fighter's blind zone, to the rear and below. Anything that reduced the size of that blind zone would reduce the chance of a successful surprise attack. And, obviously, anything that improved a fighter's chances of survival in action increased its effectiveness by a correspondingly amount.

As on several other late-war fighter types, the rearward view was greatly improved by cutting back the Spitfire's rear fuselage and fitting a bubble canopy. A Spitfire VIII modified in this way went to the Air Fighting Development Unit at Duxford for service evaluation in the summer of 1943. Several experienced service pilots flew the aircraft and were extremely impressed with the improvement in the field of view. Their report on the aircraft stated: "This is an enormous improvement over the standard Spitfire rear view. The pilot can see quite easily round to his fin and past it, almost to the further edge of the tailplane, i.e. if he looks over his left shoulder he can practically see to the starboard tip of the tail. By banking the aircraft slightly during weaving action, the downward view to the rear is opened up well."

Spitfire Mk IXs and XVIs fitted with the new canopy began reaching the operational squadrons early in 1945, where they immediately became popular with pilots.



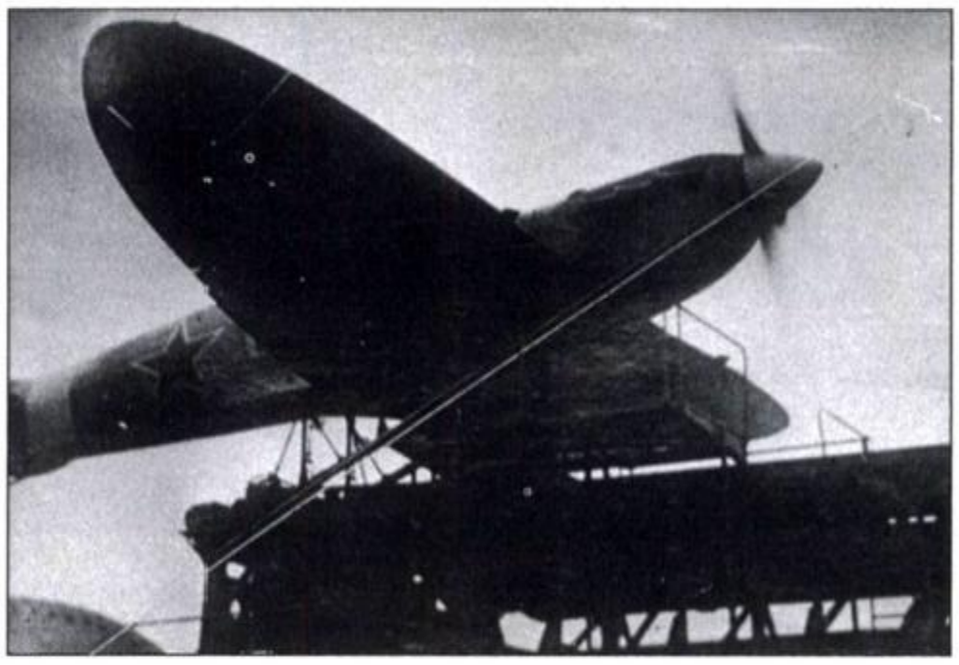
Aircraft '01' was one of the two PR.Mk IVs handed over to the Soviet air force. It is believed to be one of four Spitfire Mk IVs originally detached to Vaenga in northern Russia in the autumn of 1942, to fly reconnaissance missions over northern Norway. Note the oblique camera fitted behind the fuselage. In all, 1,333 Spitfires were delivered to the Red air force.

Above: Turkey remained neutral until 1 March 1945, when war was declared on Germany. Diplomatic efforts to curry favour with the Turkish government before this date included the supply of enough Spitfire Mk Vs to form a squadron in 1944. Eventually, 84 were supplied.

4. Additional fuel tanks in the rear fuselage

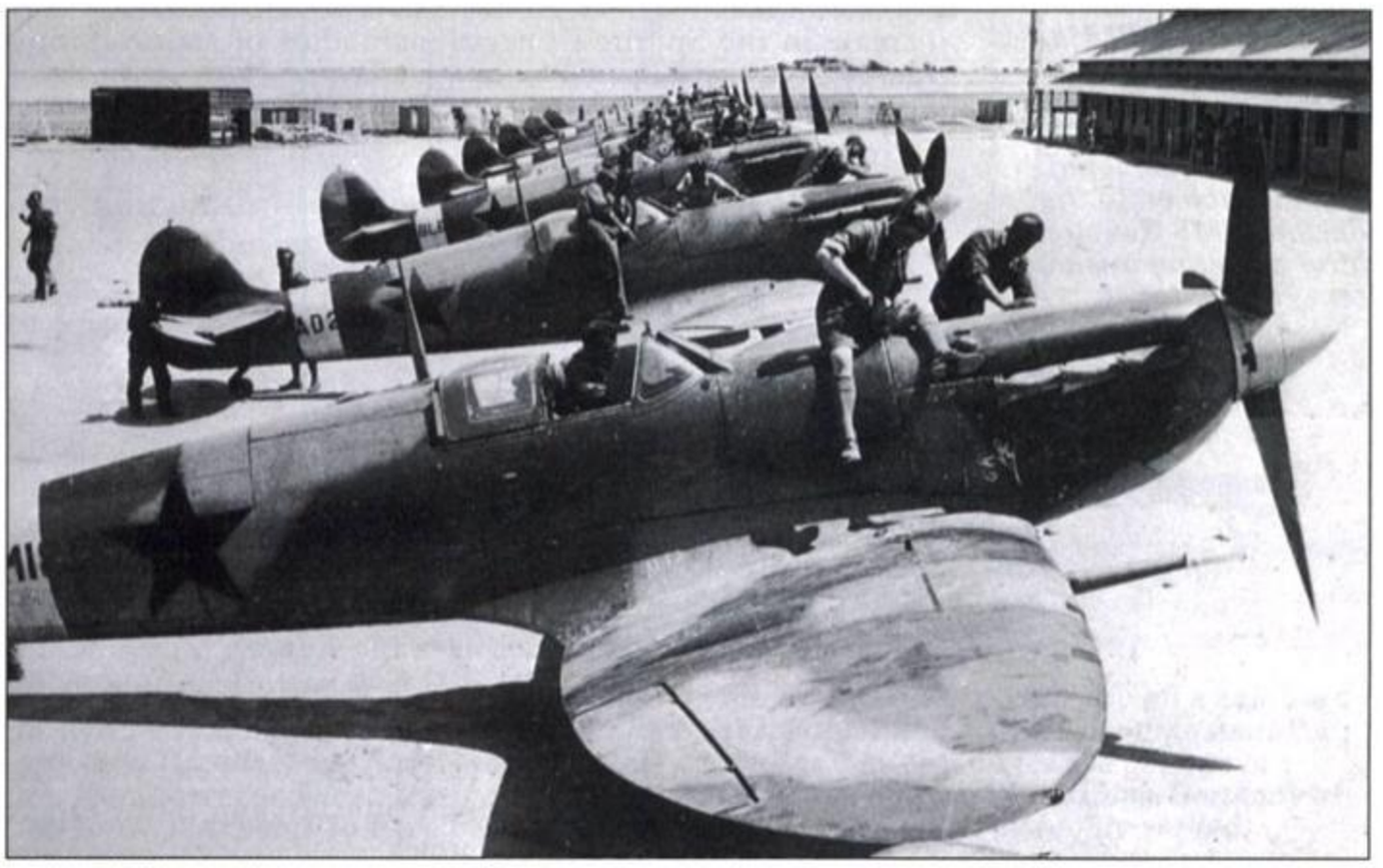
Throughout the war the Spitfire's short radius of action had been a source of embarrassment when it flew offensive operations over enemy territory. The drop tank was one answer, but it caused additional drag and had to be jettisoned before the aircraft went into action. The Mks VII and VIII had small additional tanks fitted in the wing, but there was room for even more fuel inside the airframe.

By repositioning some items of equipment that had been in the rear fuselage, there was room to install a couple of additional fuel tanks there. In Mk IXs and XVIs with the old-style canopy, these tanks had a total capacity of 72 Imp



Below left: One of the Spitfire Mk VBs delivered to the Soviet Union was used for catapult trials aboard the cruiser* Molotov *in 1946.

Below: Spitfire Mk Vs en route to the Soviet air force await collection by Soviet pilots at Abadan, Iran early in 1943. These ex-RAF machines had, in many cases, seen considerable action. The nearest aircraft, BM185, had previously served with Nos 403 and 111 Squadrons, while the next aircraft, AD236, had flown with four squadrons and had received repairs after serious damage.

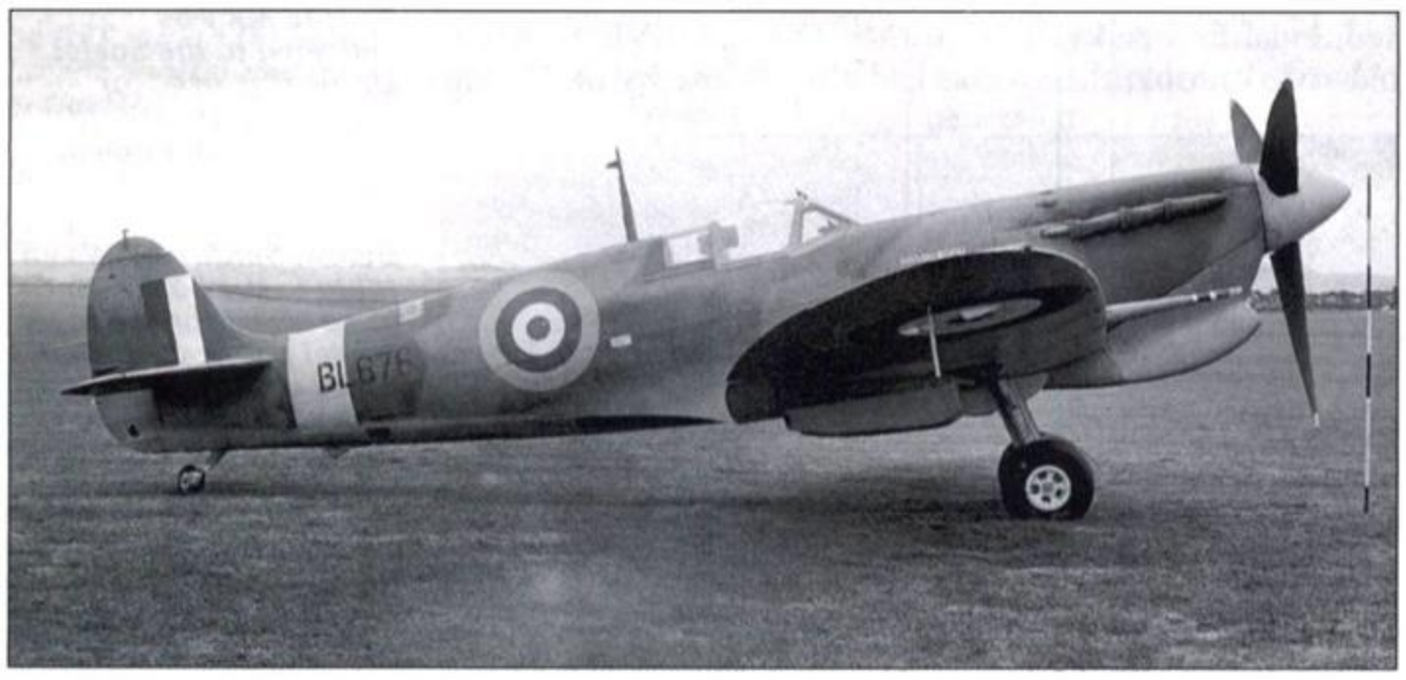


Right: AR238, a Spitfire Mk IA, leads a section of No. 761 Squadron, the Advanced Training Squadron of the Fleet Fighter School, on a flight from its base at Yeovilton, in late 1942. A number of surplus Spitfire Mk Is, IIs and Vs were transferred to the Fleet Air Arm for training purposes.

Below: BL676 **Bondowoso** *was a Mk VB acquired by the FAA for deck landing acceptance and other trials prior to the conversion of 166 Spitfire Mk Vs to Seafire Mk IB standard by Air Service Training Ltd and Cunliffe-Owen Aircraft. These first Seafires differed little from their tropicalised RAF counterparts, the only new equipment being an A-frame arrester hook, slinging points and different radio equipment. New serials were also allotted, BL676 becoming MB328.*

'Hooked' Spitfires

The Fleet Air Arm's first Seafires were converted Spitfire Mk VBs, a stopgap until production Seafire Mk IICs were available. FAA training units also flew around 100 unmodified Spitfires for training, some of which were fitted with arrester hooks to enable their use for deck landing training aboard carriers.



'Hooked' Spitfires (which retained their RAF serials) were used by the FAA for carrier training. Here, BL818, then of No. 768 Squadron, the Deck Landing Training School, is seen being hauled back on to the deck of HMS **Ravager** *after a landing mishap on 10 August 1944.*

gal (327 litres). In later production aircraft with bubble canopies, the total capacity of the extra tanks was reduced to 64 Imp gal (290 litres). The additional fuel gave a useful increase in the Spitfire's operational radius of action during the final months of the war.

Spitfire fighter-bomber

In 1944, following the large-scale introduction into service of the Griffon-powered Spitfires and other high-performance new Allied fighter types, the Merlin-powered Spitfire units moved progressively from air superiority to fighter-bomber operations.

Flying Officer David Green flew Mk IXs with No. 73 Squadron over Italy and Yugoslavia. He described the tactics employed during a typical dive-bombing attack by Spitfires: "Carrying two 250-lb [114-kg] bombs, the Spitfire made a very fine dive bomber. It could attack accurately and didn't need a fighter escort, because as soon as the bombs had been released it was a fighter. The briefing beforehand had to be good enough for us to be able to fly right up to the target even if we had never been there before, identify it and bomb it. Because the flak was often accurate, we didn't want to spend time circling in the target area before we went down to attack.

"We normally operated in sections of four, and would fly to the target at 10,000 ft [3050 m] in finger-four battle formation. We would make for an Initial Point decided at the briefing, a distinctive point on the ground in the target area with, ideally, a linear feature like a road, a river or a railway line leading to the target itself. By the time it reached the IP, the formation would have increased speed to 260 mph Indicated (about 305 mph/491 km/h, True) and we would be flying in loose echelon to starboard, ready to begin the dive. As the target came into view I would position it so that it appeared to be running down the line of my port cannon. As the target disappeared under the wing I would hold my heading, and when the target emerged from under the trailing edge I would pull the aircraft up to kill the forward speed, roll it over on its back and let the nose drop until the target was lined up in the gunsight graticule. That way one got the Spitfire to go down in the correct angle of dive of 60°. It is a pretty steep dive, it felt as if one was going down vertically. The other aircraft in the section, Nos 2, 3, and 4, would be following me down still in echelon.

"It was important to trim the aircraft nose-down, otherwise the pressure on the stick would become enormous as the speed built up and the Spitfire tried to pull itself out of

As later Spitfire marks entered RAF service, earlier aircraft were transferred to advanced flying schools and operational training units. Here, a trainee fighter pilot takes his first solo in a No. 61 OTU aircraft.

the dive. During the dive the speed built up rapidly and it was important to keep an eye on one's height, because the altimeter lag was considerable. When the altimeter read 5,000 ft (1524 m) above the target altitude, indicated, that meant the true altitude above the target was about 4,000 ft (1920 m). I would let my go my bombs and call 'Bombs gone!'; the other chaps in the section would then release theirs. At the time of release the aircraft would be doing about 420 mph Indicated (about 450 mph/724 km/h, True).

"If there had been little or no flak, the desire to see the results of the bombing was usually so great that I would pull hard on the stick to bring the aircraft out of the dive and into a slight climb, so that I could look over my shoulder to see where the bombs had gone. But if we were being fired at, we would use our high forward speed to get us down to ground level where there was cover."

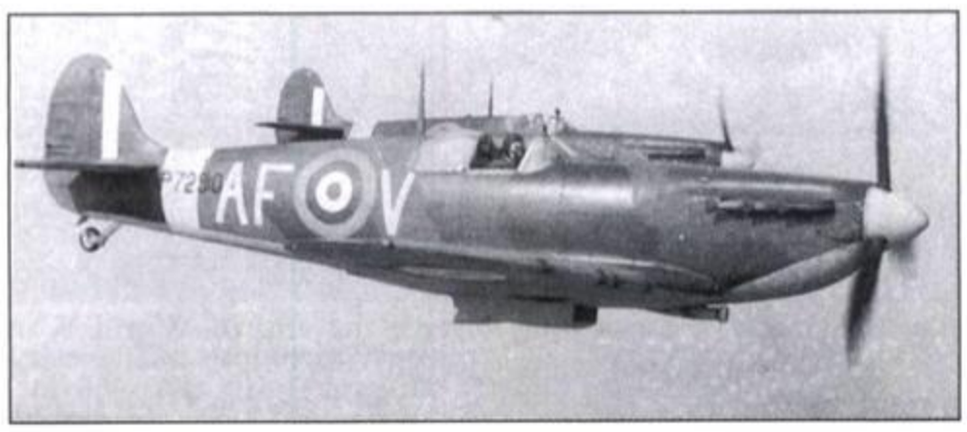
The Mk IX, and the almost identical Mk XVI, marked the zenith of development of the Merlin-engined Spitfire fighter. Ironically, the stopgap variants of the Spitfire were built in the largest numbers. Large-scale production of the

Spitfires in Swastikas

A number of Spitfires are known to have been captured and flown by the Luftwaffe, including examples of Mks I, V and XI. As well as being evaluated against German types at the Luftwaffe's Rechlin test centre, some of these machines took part in propaganda films which were released as 'real footage' purporting to show RAF fighters being successfully engaged by the Luftwaffe.

Rare colour shots, from a German source, show the camouflage worn by RAF fighters during the Battle of Britain. Spitfire N3277 is seen (below) after it made a forced landing near Cherbourg on 15 August 1940, during the application of German markings. The same aircraft (above right) is seen after the application of markings is complete, being inspected by Luftwaffe pilots.

Once they had been replaced in front-line units, Spitfires were employed in a host of second-line tasks. This LF.Mk VB served with No. 1688 Flight, Bomber Command, for target towing, fighter affiliation and other miscellaneous duties. Note the fixed towing hook mounted behind the tailwheel.



Left: The Air Fighting Development Unit (AFDU), which was based at Duxford and, later, Wittering, was equipped largely with Spitfires and Hurricanes. In the course of the war, the AFDU flew a number of types in its role as a tactical training school.

Above: At least one captured Spitfire was repainted in spurious British markings for propaganda photographs, which were later published in wartime German periodicals.

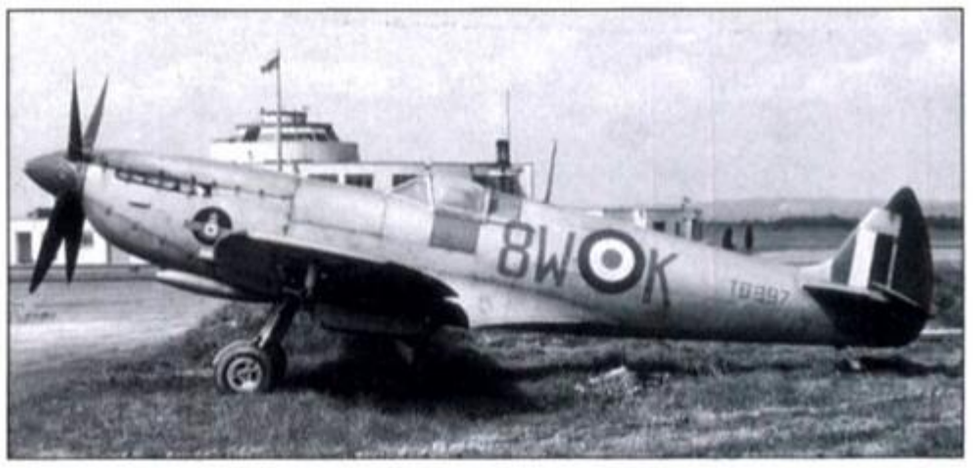
A remarkable modification was carried out by the Daimler-Benz company on a captured Mk VB (EN830) in the autumn of 1943. The British fighter had a DB.605 engine installed, and later it underwent flight testing in this condition. The reason for the change is unclear, however. Given the increasingly desperate military position facing Germany at the time, it appears to have been an extravagant waste of effort by highly skilled technicians.

Above: Stripped of its camouflage and carrying Flying Training Command codes, RW396 was with the Central Gunnery School at Leconfield when this photograph was taken, some time after 1946. Most of those Merlin-engined Spitfires that served with the RAF post-war were Mk XVIs, like this late-production Mk XVIE delivered in July 1945.

Mk IX began in June 1942 and the last of more than 6,700 Mk IXs and Mk XVIs was delivered in June 1945.

The career of the Merlin-engined Spitfire fighter in front-line RAF units did not long survive the end of World War II. Large numbers of these aircraft were exported. They served with nearly a score of foreign air forces and saw action in half a dozen small-scale conflicts. The last service to employ Merlin-engined Spitfires in action was the Burmese air force. That service purchased 30 reconditioned Mk IXs from Israel in 1954, and used them in attacks on rebel troop positions during the long-running Burmese civil war.

In the post-war RAF



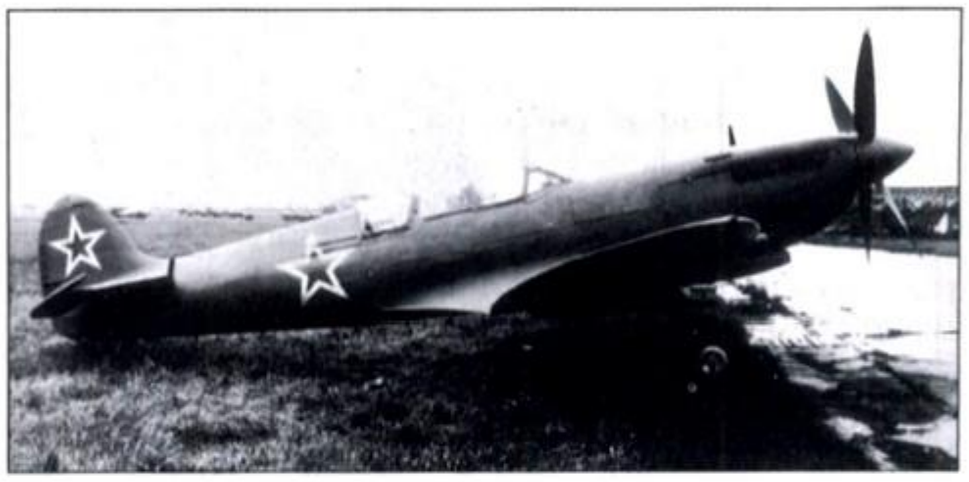
No. 612 'County of Aberdeen' Squadron, originally an army co-operation unit disbanded in 1945, reformed as an Auxiliary Air Force fighter squadron in 1946, equipped with Spitfire Mk XVIs. It flew them until 1951, the year in which the RAF retired its last Merlin-engined Spitfires.

Merlin-powered Spitfire development

Rolls-Royce provided the impetus for the long-running campaign to improve the Spitfire's performance, relying on the ability of its engineers to squeeze extra power from successive variants of the Merlin engine. The Merlin III fitted to the Spitfire I developed 1,030 hp (768 kW) at 16,250 ft (4950 m). With the same 27-litre capacity, the Merlin 61 fitted to the Spitfire IX gave 1,565 hp (1167 kW)

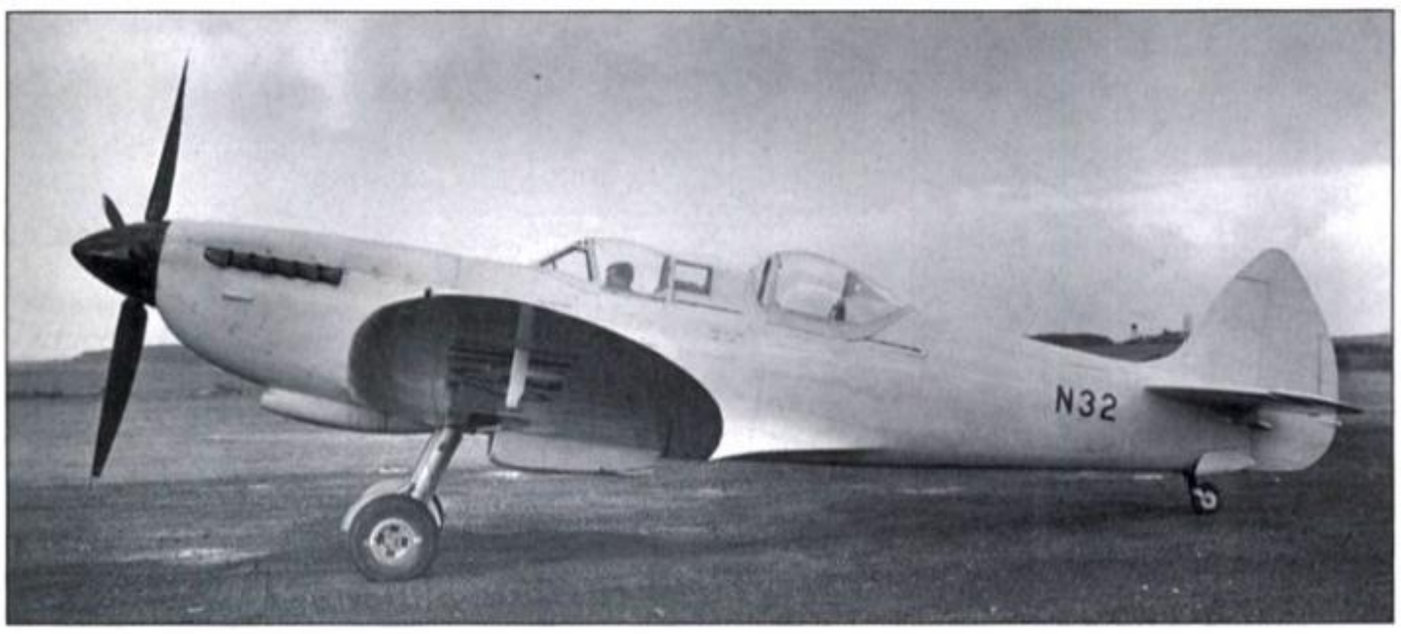
Spitfires built for two

The two-seat Spitfire was first proposed in 1941, as a means of providing a transition trainer for future Spitfire pilots. Nothing came of the plan during the war, though a Mk V is known to have been fitted with a second seat by No. 261 Squadron, RAF in 1944 and a Mk IX was similarly converted by the Soviet air force. The plan was revived in 1946, when a Mk VIII was converted by Supermarine and demonstrated to RAF Reserve Command, which had a requirement for 20 examples. However, an RAF order never came. Overseas interest, on the other hand, led to 'production' conversions of 20 Mk IX aircraft for the air forces of Egypt, India, the Netherlands and the Republic of Ireland. Orders from Argentina (10 aircraft) and Iraq (six) were cancelled. Several of these aircraft, now privately owned, were airworthy in 1997.



Above: This Spitfire Mk IX UTI was converted by the Soviet air force in 1944/45. The number so-treated is unknown. No. 261 Squadron, RAF's 1944 Mk V conversion differed in having a second open cockpit in front of the original cockpit.

Bearing the Class 'B' registration N32, this T.Mk 8 was the first of a number of two-seat trainer conversions made after 1946. Formerly Mk VIII MT818, N32 was later registered G-AIDN and sold. It remained airworthy in 1997.



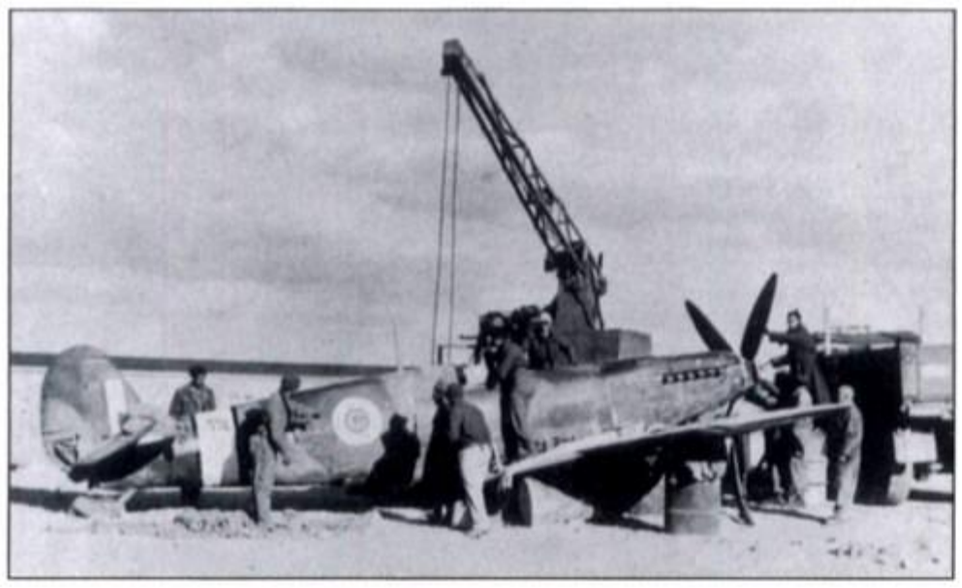
Above: Egypt took delivery of just one T.Mk 9, in 1950. Serialled 684, it had been used as Supermarine's demonstrator, registered G-ALJM.

H-99 (with its former RAF serial number BS147 on the fin) was one of three T.Mk 9s operated by the Royal Dutch Air Force between 1948 and the early 1950s. The others were serialled H-97 and H-98.

Above: The Irish Air Corps used six Spitfire trainers in the 1960s. Fitting a second cockpit to the Spitfire necessitated moving the original cockpit 13.5 in (34.3 cm) forward.

Spitfires at war post-1945

Significant numbers of ex-RAF Merlin-engined Spitfires were to see further service after 1945, principally in wars of self-determination in the Middle East and Far East. Perhaps the most famous of these were the Mk IXs flown by Israel's fledgling defence force. The first Israeli Spitfires were two aircraft assembled from abandoned RAF and captured Egyptian airframes; others were obtained from Czechoslovakia and, after 1949, Italy.



Above: This Spitfire Mk IX, 664 coded 'L', of No. 2 Squadron, Royal Egyptian Air Force was captured on 29 September 1948. It had come down, more or less intact, in Israeli territory and was promptly trucked to Tel Aviv and rebuilt for IAF service. During the fighting of 1948, a number of other downed REAF Mk IXs were cannibalised for parts to keep the IAF's hard-pressed aircraft in the air.

at 11,250 ft (3430 m) – an increase in power of more than 40 per cent.

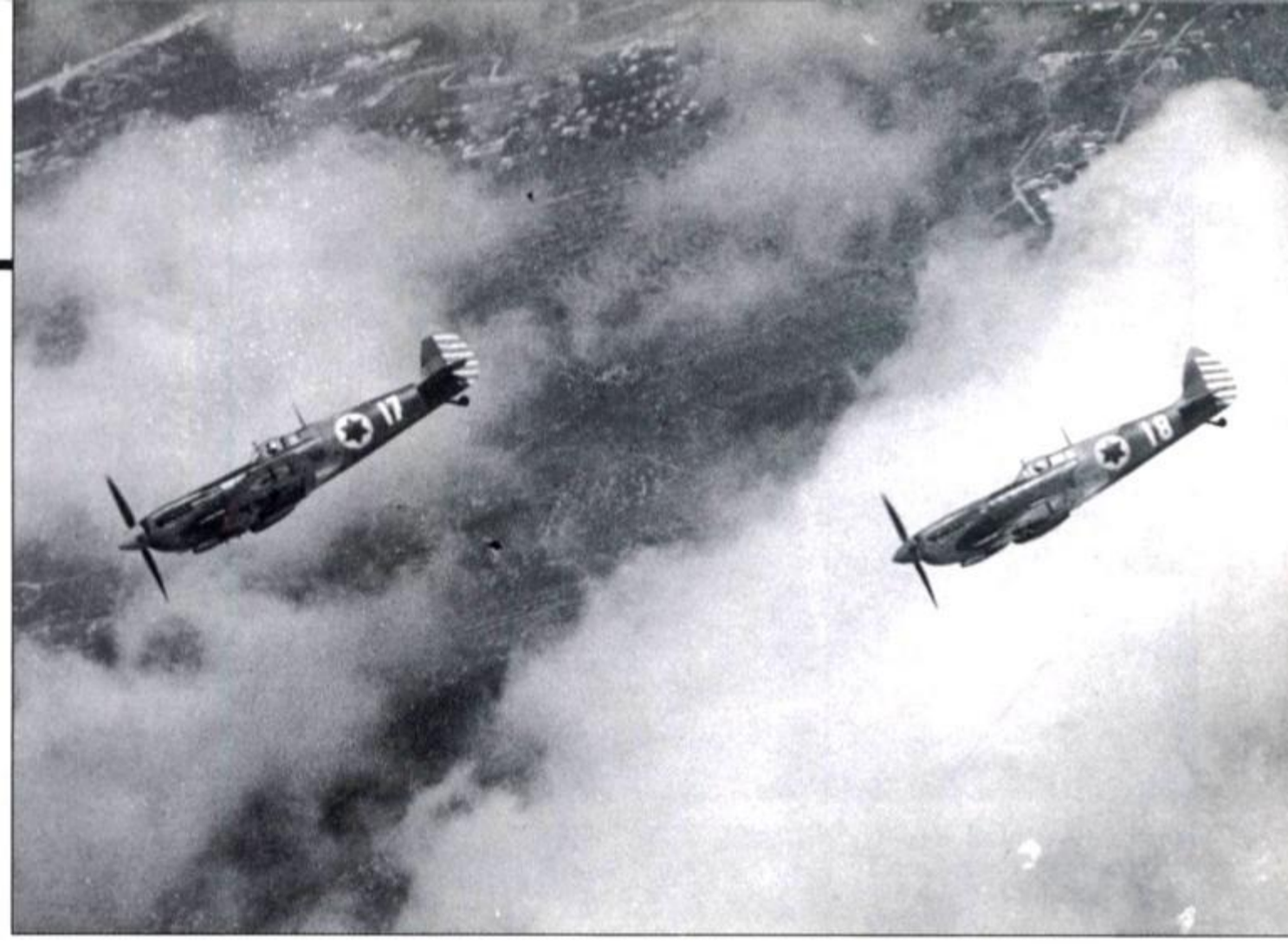
In aircraft engineering one rarely gets something for nothing, however. With their greater power, the later Merlin engines were somewhat heavier than their predecessors. For example, the Merlin 61 installation, with the additional plumbing necessary for the intercooler, was about 300 lb (136 kg) heavier than the Merlin III installation.

Lead ballast

To convert the additional rotational power into thrust as efficiently as possible, it was necessary to fit a propeller with greater solidity. The Spitfire I entered service fitted with a fixed-pitch two-bladed propeller weighing 83 lb (37 kg). The Mk IX had a four-bladed constant speed airscrew weighing about 600 lb (272 kg). The addition of so much extra weight at the extreme nose would have made the aircraft too nose-heavy, so, to restore the centre of gravity to its normal place, the early Mk IXs carried 185 lb (84 kg) of lead ballast in rear fuselage.

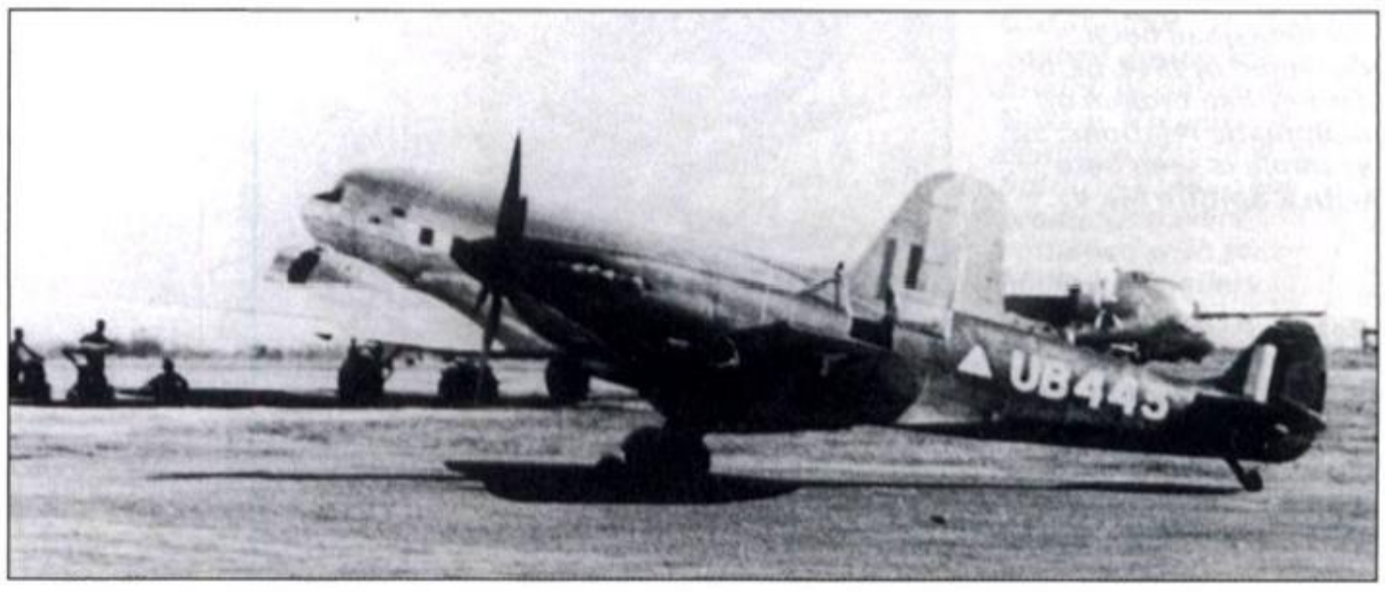
Application of the hard-won lessons of air combat led to further increases in weight. The RAF demanded the installation of plate armour to protect the pilot and vulnerable parts of the structure. It also ordered the installation of additional equipment and more powerful (and therefore heavier) batteries of cannon and machine-guns.

Below: After World War II, France's Armée de l'Air became the largest foreign operator of Spitfires. It took delivery of about 500 Mk Vs, VIIIs, IXs and XVIs. This Mk IX belonged to the Groupe de Chasse 'La Fayette', based at Hanoi in December 1947, in what was then French Indo-China. Within a few months the unit would provide support for French ground forces during the opening stages of the war in Vietnam.

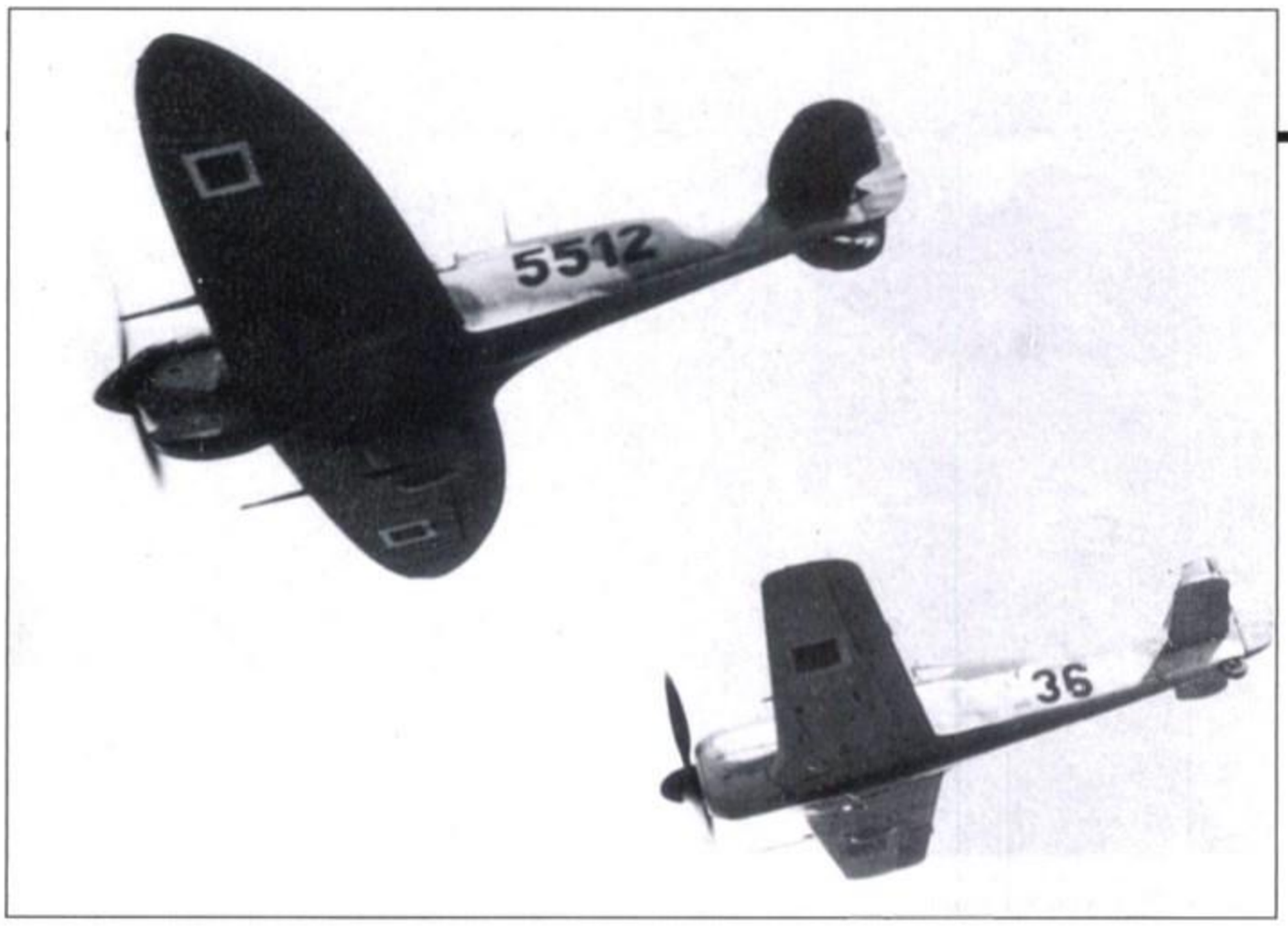


Above: The motley collection of Mk IXs gathered together by Israel's Heyl Ha'Avir (air force) in the late 1940s gave sterling service alongside P-51D Mustangs and Avia S.199s during the 1948 War of Independence, during which they were famously pitted against Egyptian Spitfire Mk Vs and IXs (used in the bombing role on several occasions) and Griffon-engined RAF examples. By 1956, the last IDF Spitfires had been retired.

Below: Having established an air force in the early 1950s with, among other types, a flight of Griffon-engined Mk XVIIIs, the Union of Burma took delivery of ex-Israeli Mk IXs in 1955. These aircraft and a number of Sea Furies supported Chinese and Burmese troops in attacks on CIA-supported Kuomintang (KMT) nationalists during 1960/61.



Armée de l'Air Mk IX fighter-bombers fly 'somewhere over French Indo-China'. The first French air force fighter unit in the region (GC II/7) was formed at Tan Son Nhut, near Saigon in December 1945, using Spitfire Mk VIIIs borrowed from the RAF pending the delivery of Mk IXs in January. Spitfires served with the French in the region until 1950.

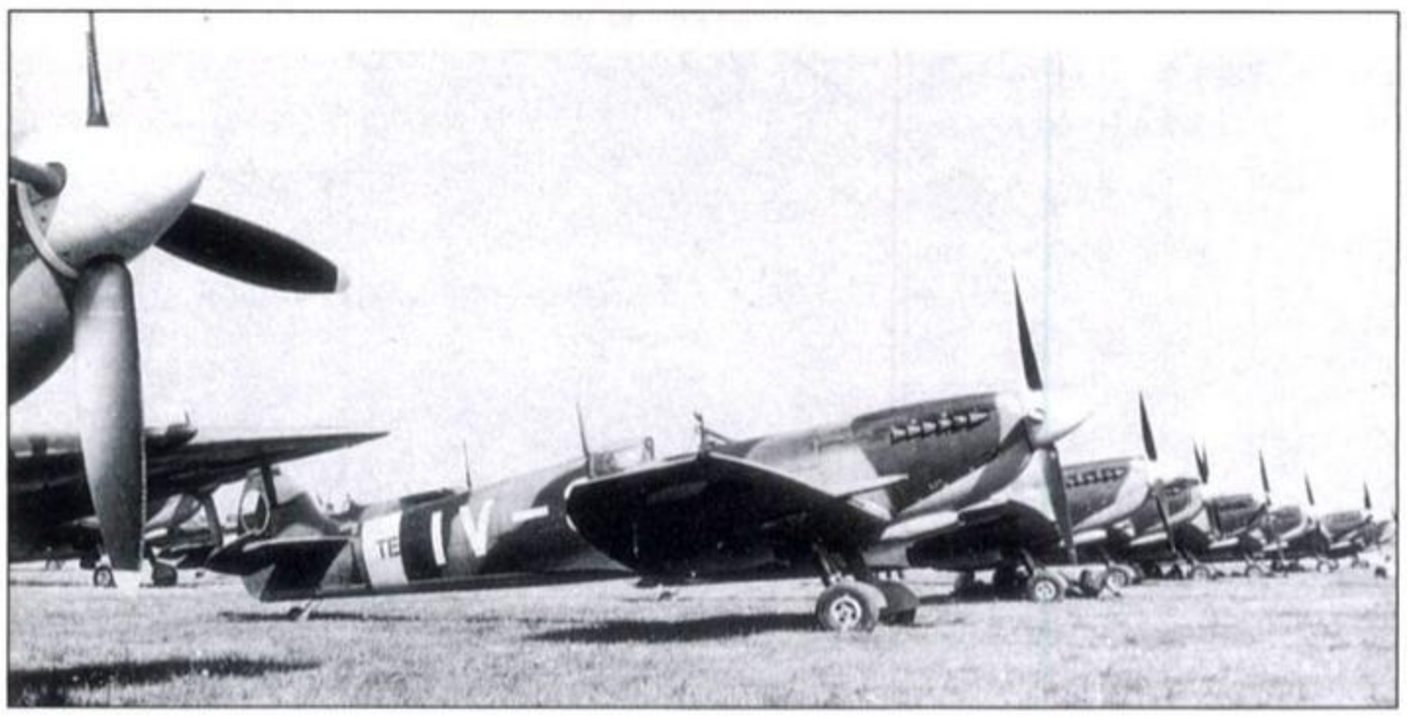


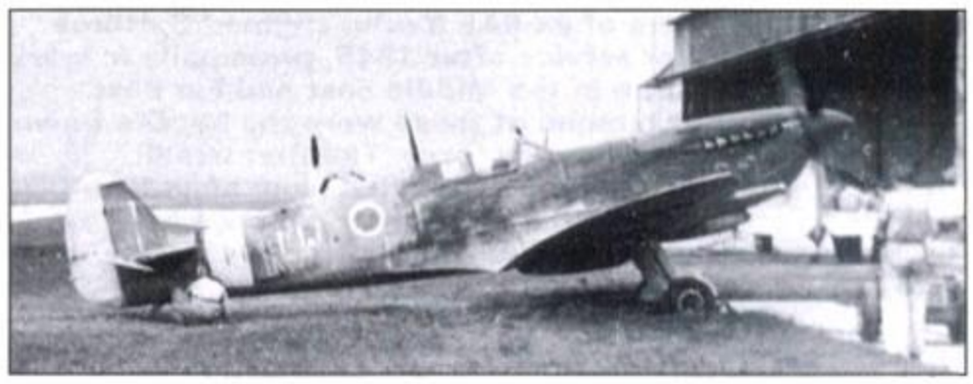
Above: Former foes meet in the skies over Turkey. Having signed a non-aggression pact with Germany in 1941, only to declare war on the Nazis in 1945, Turkey had an air force of varied types by 1945. One hundred Fw 190As had been delivered in 1944, before Turkey had broken off diplomatic relations; an example is seen here with a Spitfire Mk V.

Surplus Spitfires

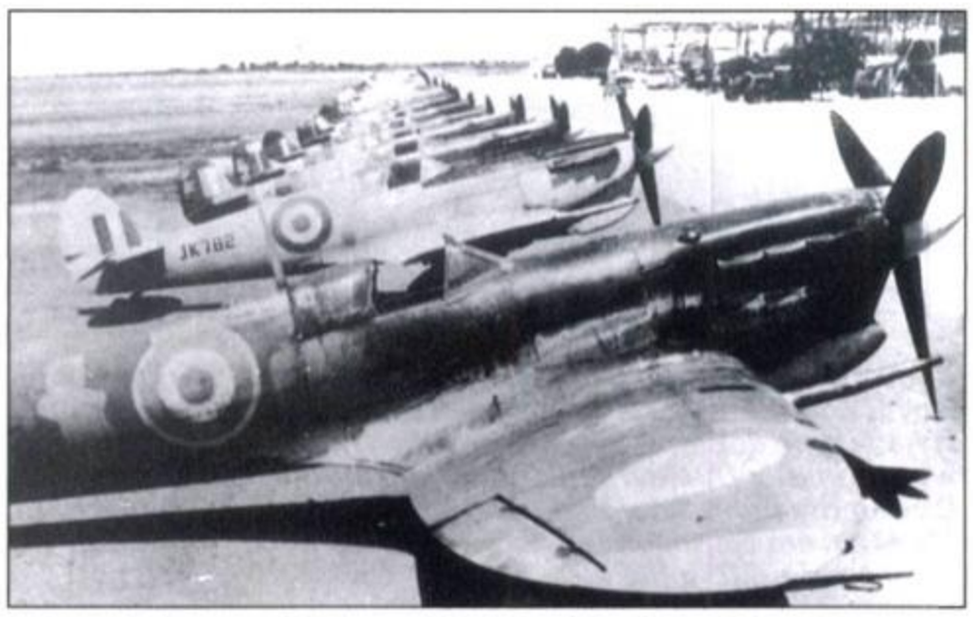
Above: Post-war, Turkey received a large amount of military equipment from Britain, including around 140 Spitfires, most of which were Mk IXs. This is a 'clipped'-wing Mk IXE, with bomb racks and a belly tank fitted.

Below: Part of the 77-strong force of Spitfire Mk IXs supplied to the Czech air force after the war, these machines served with the 3rd Air Division at Brno in 1947.





Above: An ex-No. 318 Squadron Spitfire Mk IXE is seen shortly after being handed over to the Italian air force in August 1946. Italy took delivery of 99 Mk IXs after the war, some of which later served in Israel.



Above: A large collection of Spitfire Mk VCs of No. 335 Squadron, Royal Hellenic Air Force is seen at Elevsis in 1945. Mk Vs were retained by the RHAF for training purposes as late as 1951. Mk IXs were obtained in 1947.

Cumulatively, those increases in weight became significant. The Mk I in early production form had an all-up weight of 5,819 lb (2639 kg), while that of a late production Mk IX was 7,400 lb (3356 kg). That increase amounted to nearly 30 per cent. With the fighter sitting on the ground the difference was unimportant, but in combat it was a different matter. If a pilot pulled 6*g* in a turn, every part of the aircraft weighed six times more. If the structure was insufficiently strong to withstand the additional forces, it would collapse. To cope with the progressive increases in weight, the airframe of the Spitfire had to be strengthened

Above: Mk IXs of the JachtVlieg School (Fighter Training School) of the Royal Dutch Air Force based at Twenthe, Holland. After the war that service received 76 examples of the variant. This 'clipped'-wing example lands at Twenthe in August 1950.

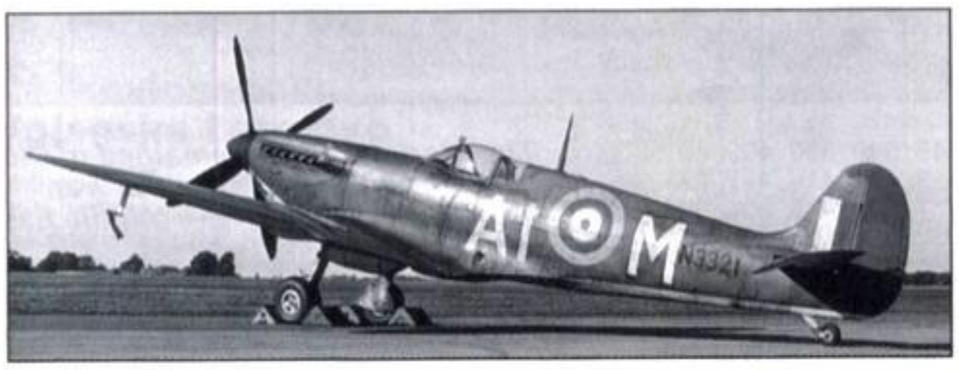
Norwegian Nine

Spitfire F.Mk IXE
Having flown Spitfires in the RAF, Norwegian pilots continued to use the type post-war. Fifty Spitfires were purchased – 47 Mk IXs and three Mk XIs. They were operated until 1954. This aircraft few with the post-war No. 332 Squadron, RNAF, from Gardermoen in 1948.

Tugs and film stars

Above: Possibly the most spectacular use of Spitfires in a modern motion picture was during the filming of the epic **Battle of Britain** *production during 1968. Gp Capt T. G. 'Hamish' Mahaddie's company Film Aviation Services amassed this impressive collection of airworthy and static Spitfires of various marks, including a T.Mk 9. Here they are seen at RAF Henlow, with three Hawker Hurricanes.*

Below: Painted to represent a Battle of Britain period Spitfire Mk I for the film, this aircraft has a spurious serial number and code letters.



from time to time to restore the safe load factor of the airframe. And, naturally, each such strengthening brought with it its own weight increase.

Standard wing

Apart from the high-altitude variants fitted with pointed wingtips, the Merlin-powered fighters had no increase in wing area. The early production Mk I had a wing loading of 24 lb/sq ft (1.01 kg/m²) while that of the Mk IX was 30.5 lb/sq ft (1.28 kg/m²). Each improvement in performance, fire power, range or capability added a further twist to the spiral of increased weight, causing a progressive deterioration in the fighter's handling characteristics. Alex Henshaw, chief test pilot at the Castle Bromwich factory, personally test flew more than 2,000 Spitfires. He summed up the changes in the fighter's handling characteristics in these words:

"I loved the Spitfire, in all of her many versions. But I have to admit that the later marks, although they were faster than the earlier ones, were also much heavier and so did not handle so well. You did not have such positive control over them. One test of manoeuvrability was to throw the Spitfire into a flick roll and see how many times she rolled. With the Mk II or the Mk V one got two and a half flick rolls, but the Mk IX was heavier and you got only one and a half. With the later and still heavier versions one got even less. The essence of aircraft design is compromise, and an improvement at one end of the performance envelope is rarely achieved without a deterioration somewhere else."

Dr Alfred Price

Above: For the film **The Longest Day**, *three ex-COGEA aircraft were painted in semi-accurate RAF markings of the mid-1944 period. Here OO-ARD (formerly MH415) poses with other COGEA aircraft, including OO-ARA (MH434). This latter aircraft was airworthy in 1997, owned by the Old Flying Machine Company at Duxford aerodrome, England.*

Above: Belgian company Compagnie Générale d'Exploitation Aérienne (COGEA) Nouvelle operated six Mk IXs in the gunnery target-towing and army co-operation roles from Ravensijde aerodrome, near Ostend. All were ex-Belgian air force aircraft purchased in 1956 and finally retired by COGEA in the early 1960s.

Below: Aircraft 'N3321' had another set of codes applied during the filming of **Battle of Britain**. *Prepared to a common standard, all Spitfires used in the production were equipped with four-bladed propellers.*

Left: Television series set during wartime have also utilised preserved Spitfires for flying sequences. At Charlton Park, England in February 1988 during the filming of **Piece of Cake**, *the late 'Hoof' Proudfoot sweeps the set in The Fighter Collection's LF.Mk IX ML417 (refitted with standard wingtips). ML417 was one of 10 Mk IXs converted to T.Mk 9s for the Indian Air Force and was 'deconverted' during restoration.*

Merlin Spitfire Operators

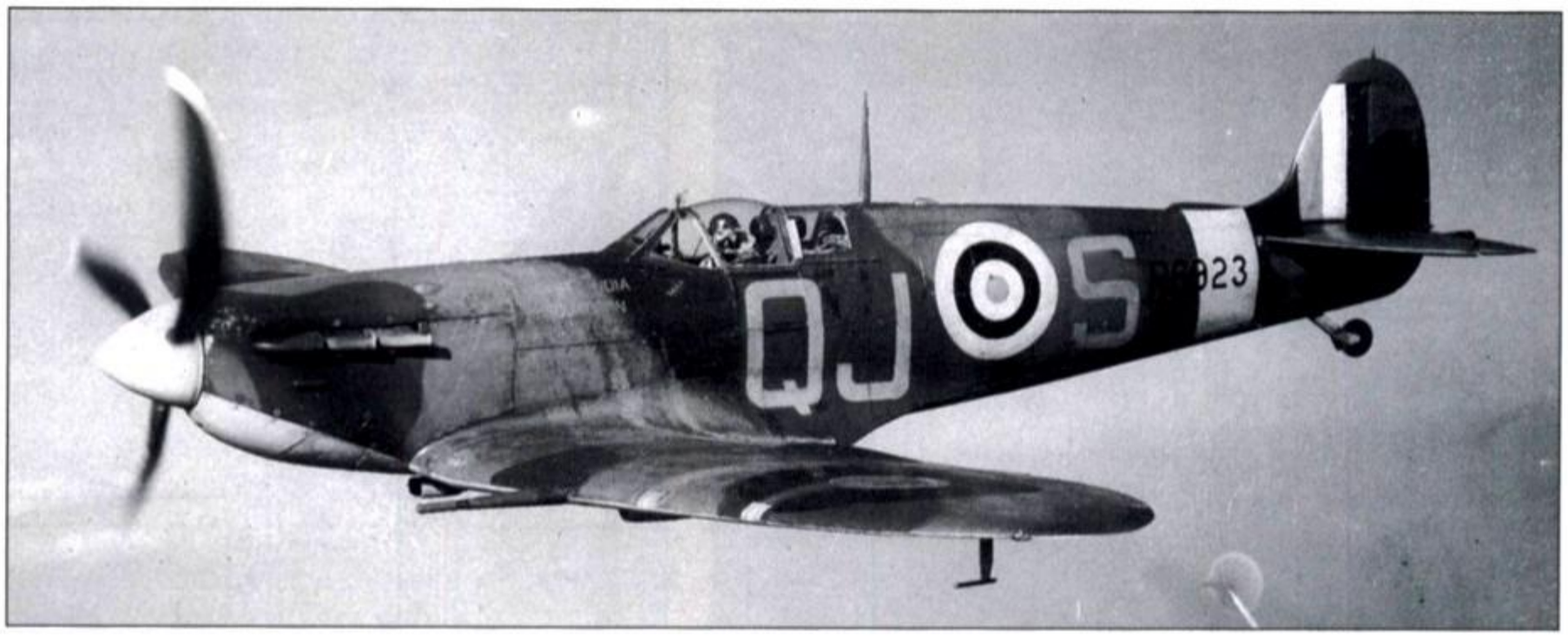
United Kingdom

Royal Air Force

The following RAF operational squadrons used Merlin-engined fighter and reconnaissance variants of the Spitfire between 1938 and 1951.

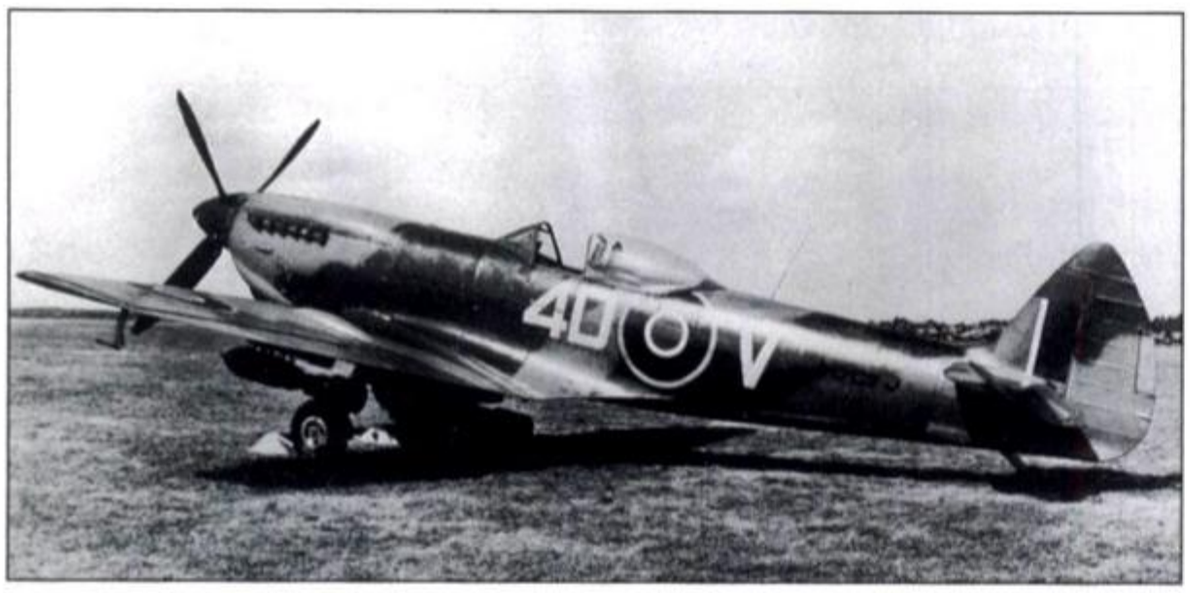
Mk I: Nos 19, 41, 54, 64, 65, 66, 71, 72,74, 92, 111, 122, 123, 124, 129, 131, 132, 140, 152, 222, 234, 238, 249, 257, 266, 303, 308, 313, 411, 452, 457, 485, 501, 510, 602, 607, 609, 610, 611, 616
Mk II: Nos 19, 41, 54, 64, 65, 66, 71, 72, 74, 91, 111, 123, 124, 129, 130, 131, 132, 133, 134, 145, 152, 154, 222, 234, 266, 276, 277, 303, 306, 308, 309, 310, 312, 313, 315, 331, 340, 350, 352, 401, 403, 411, 412, 416, 417, 452, 457, 485, 501, 504, 602, 603, 609, 610, 611, 616
Mk IV: Nos 69, 140, 541, 542, 543, 544, 680, 681, 682, 683
Mk V: Nos 19, 26, 32, 33, 41, 43, 54, 63, 64, 65, 66, 71, 72, 73, 74, 80, 81, 87, 91, 92, 93, 94, 111, 118, 121, 122, 123, 124, 126, 127, 129, 130, 131, 132, 133, 134, 136, 145, 152, 154, 164, 165, 167, 184, 185, 186, 208, 213, 222, 225, 229, 232, 234, 237, 238, 241, 242, 243, 249, 253, 257, 266, 269, 274, 275, 276, 277, 278, 287, 288, 290, 302, 303, 306, 308, 310, 312, 313, 315, 316, 317, 318, 322, 326, 327, 328, 329, 331, 332, 340, 341, 345, 349, 350, 352, 401, 402, 403, 411, 412, 416, 417, 421, 441, 442, 443, 451, 453, 457, 485, 501, 504, 520, 521, 527, 541, 543, 567, 577, 595, 601, 602, 603, 607, 609, 610, 611, 615, 616, 680, 695, 1435
Mk VI: Nos 66, 124, 129, 234, 310, 313, 504, 519, 602, 616, 680
Mk VII: Nos 118, 124, 131, 154, 313, 519, 542, 611, 616
Mk VIII: Nos 17, 20, 28, 32, 43, 54, 67, 73, 81, 87, 92, 94, 131, 132, 136, 145, 152, 153, 154, 155, 185, 208, 238, 241, 253, 256, 273, 326, 327, 328, 417, 451, 452, 457, 548, 549, 601, 607, 615
Mk IX: Nos 1, 6, 16, 19, 28, 32, 33, 43, 56, 64, 65, 66, 72, 73, 74, 80, 81, 87, 91, 92, 93, 94, 111, 118, 122, 123, 124, 126, 127, 129, 130 131, 132, 133, 145, 152, 153, 154, 164, 165, 183, 185, 208, 213, 222, 115, 229, 232, 234, 237, 238, 241, 242, 243, 249, 253, 256, 274, 283, 287, 288, 302, 303, 306, 308, 310, 312, 313, 315, 316, 317, 318, 322, 326, 327, 328, 329, 331, 332, 340, 341, 345, 349, 350, 400, 401, 402, 403, 411, 412, 414, 416, 417, 421, 441, 442, 443, 451, 453, 485, 501, 504, 518, 541, 544, 595, 601, 602, 611,1435
Mk X: Nos 541, 542
Mk XI: Nos 2, 4, 16, 26, 28, 140, 253, 268, 400, 541, 542, 543, 680, 681, 682, 683, 684
Mk XVI: Nos 5, 16, 17, 19, 20, 33, 34, 63, 65, 66, 74, 126, 127, 164, 229, 287, 288, 289, 302, 303, 308, 317, 322, 329, 340, 341, 345, 349, 350, 401, 402, 403, 411, 412, 416, 421, 443, 451, 453, 485, 501, 567, 577, 587, 595, 601, 602, 603, 604, 609, 612, 614, 631, 667, 691, 695

In addition to the front-line squadrons, there were several operational flights equipped with Merlin Spitfires, and many training units (mostly OTUs). Station flights and development units also made extensive use of Spitfires. The Royal Navy also employed 'hooked' as well as standard ex-RAF Merlin Spitfires for training purposes only, supplying aircrew for the Seafire units.



Above: No. 92 'East India' Squadron has a strong claim to being the RAF's senior Spitfire squadron. It converted to Mk Is in March 1940, and then flew Mk Vs (VB illustrated), Mk IXs and Mk VIIIs until late 1946. Through service on the home front, in North Africa and Italy, it became the highest-scoring RAF squadron of the war.

No. 74 Squadron was another famous Spitfire unit which flew the Mk I, II, V and IX (with a brief spell on Hurricanes in the Middle East). In March 1945 it transitioned to the Mk XVIE (illustrated) for fighter-bomber duties in the war's last months.

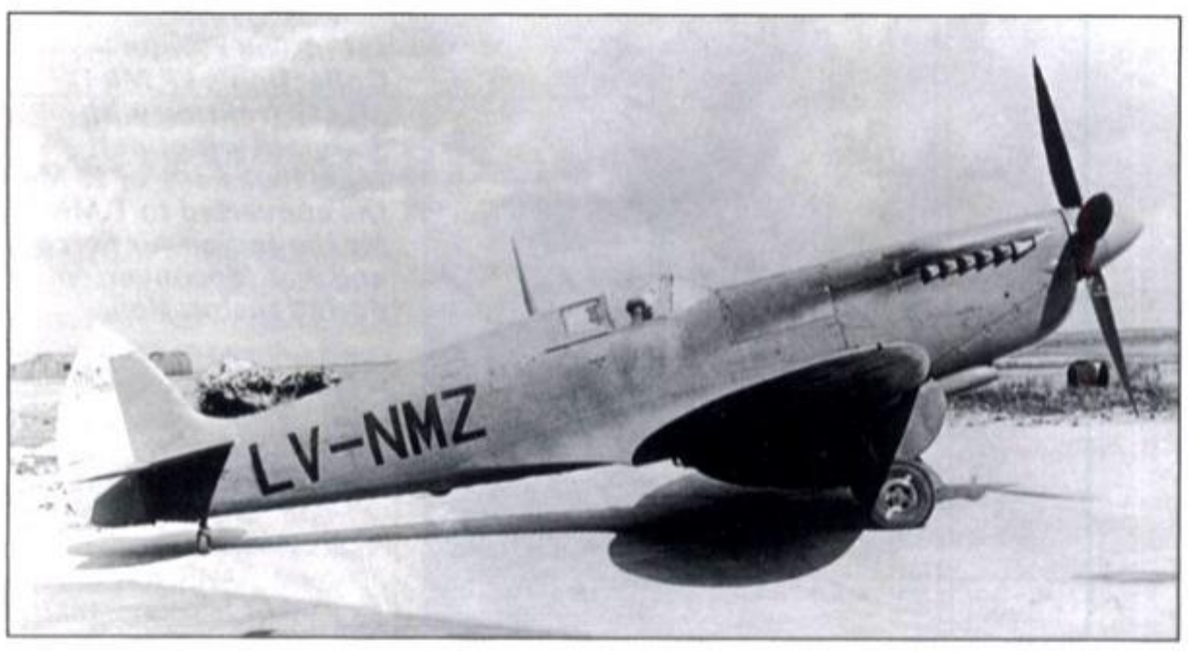


The Merlin Spitfire remained in the RAF for some time after the war. This Mk 9 is seen in the Middle East in 1948.

Argentina

At least three Spitfires arrived in Argentina after the war, including a Mk VIII, a IX and an XI. The Mk XI was delivered to Argentina for government photo-survey work in April 1947. The aircraft, PL972, was fitted with overload fuel tanks and flown by Captain J. Storey from Hurn to Buenos Aires via Gibraltar, Dakar and Natal. The aircraft was given the Argentine civil registration LV-NMZ. The Mk VIII, JF275, and the IX, PL194, were shipped out. An order for 10 T.Mk 9s was made but cancelled before delivery.

This is the PR.Mk XI which made the long self-ferry flight to Argentina. It was used by the government for photo-survey work.



Australia

Royal Australian Air Force

In all, 656 Spitfires were delivered to the Royal Australian Air Force between August 1942 and June 1945, comprising 246 Mk VCs, 251 Mk VIIIs and 159 HF.Mk VIIIs. At least another dozen were lost in transit. No. 1 Fighter Wing, RAAF formed with Mk VCs in 1942/43 for home defence. The three squadrons of the wing (Nos 54, 452 and 457 Squadrons) were re-equipped with Mk VIIIs in 1944, 420 of this mark (including F.Mk VIII and HF.Mk VIII sub-variants) entering service. Other squadrons were established to take the war to the New Guinea area and eventually seven front-line squadrons used the Spitfire in the Australian/Southwest Pacific theatre at some point, the others being Nos 79, 85 Squadrons, RAAF and Nos 54, 548 and 549 Squadrons, RAF. Replaced by CAC-built Mustangs from 1945, the Spitfire fleet was disposed of between 1946 and 1952.

Serials were: A58-1/185, A58-200/259, EE731 (Mk VCs); A58-300/550 (Mk VIIIs); A58-600/758 (HF.Mk VIIIs)

The delightful Mk VIII was numerically the most important RAAF version. In Australian hands it compiled a useful war record, notably as a ground attack platform during the 'mopping-up' operations in New Guinea and Morotai.

Belgium

Force Aérienne Belge/ Belgische Luchtmacht

In addition to 11 aircraft loaned by the RAF for training in 1946, the Belgian Air Force received 28 ex-RAF Merlin Spitfires in 1947-48. They were mostly Mk IXs with a few Mk XVIs among them. In 1952-53, the force also gained 15 Mk IXs formerly used by the Dutch in the East Indies and refurbished by Fokker. The Merlin Spitfires were used by Nos 349 and 350 Smaldeel and the Jacht school; the two operational units traded in Spitfires for Meteors in 1949, while the fighter school continued to use the Spitfires (alongside Griffon-engined Mk XIVs), with the last being retired in 1956.

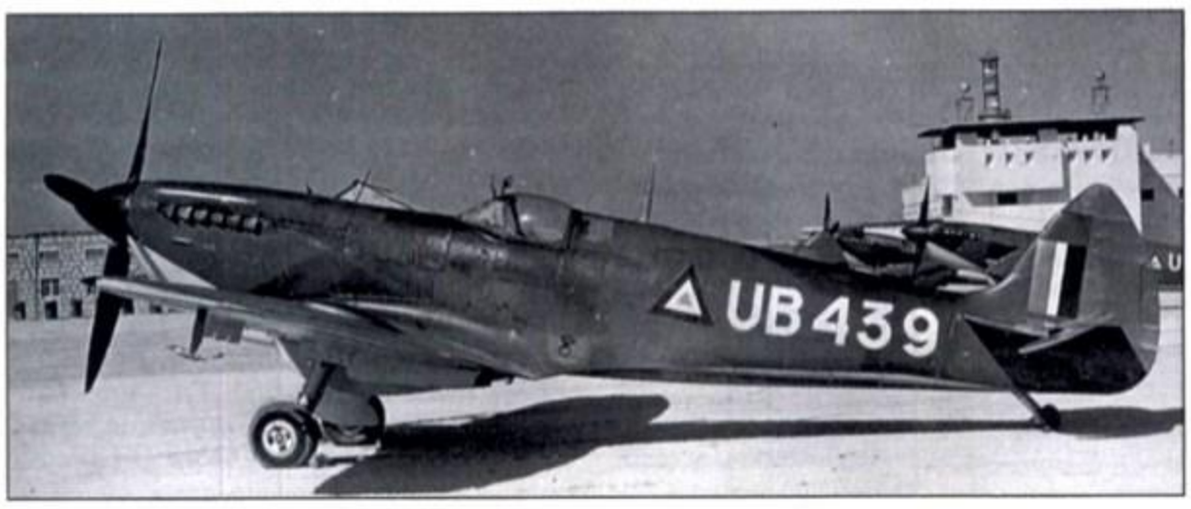
Spitfire Mk IXs formed the basis of the Belgian Air Force's rebirth in the late 1940s.

Burma

Union of Burma Air Force

The Union of Burma Air Force was formed following independence in 1948. The new force's air strength was built up with help from the RAF during a period of revolt by Communists and Karen ethnic groups. British assistance included 20 Seafire XVs delivered in 1952, which were supplemented in 1954-55 by a batch of about 30 Spitfire IXs purchased from Israel. In 1958-59 the Spitfires were replaced by new Hawker Sea Furies. The Burmese Spitfires wore serials in the UB400 range.

Burma operated Spitfire Mk IXs alongside Seafires in the late 1950s. This aircraft has rocket launchers.



Czechoslovakia

Ceskoslovenske Vojenske Letectvo

At the end of the war, the Czech-manned Spitfire squadrons of the RAF (Nos 310, 311 and 313) returned to their homeland and formed the nucleus of the reborn Czech Air Force. The Spitfire squadrons were organised within air divisions into fighter regiments from August 1945. 1st, 2nd and 3rd Divisions, 1st, 4th and 10th Regiments. The aircraft were sold to Israel in 1948.

The Czech air force flew ex-RAF Mk IXs briefly after the war, before the aircraft were sold to Israel.

Denmark

Flyvevabnet

Thirty-eight Spitfire Mk IXs and three Mk XIs were purchased together with non-flying instructional airframes in 1947 as part of the post-war re-equipment programme. Initially they equipped the Spitfireskolen at Karup. This unit was absorbed into No. 5 Eskadrille. In 1950 the Royal Danish Air Force was established as a separate entity, with Spitfires and Meteors in the fighter role.

725 Eskadrille (formerly the PR Flight of No. 4 Esk.) based at Karup operated Mk IXs, and No. 722 Esk. at Vaerlose operated Mk IXs as unarmed trainers. The Spitfire fighters were given the type number 41 in Danish service with serials in the range 401-436; the PR.Mk IXs were Type 42 and numbered 451-453. The Spitfire was retired in May 1955.

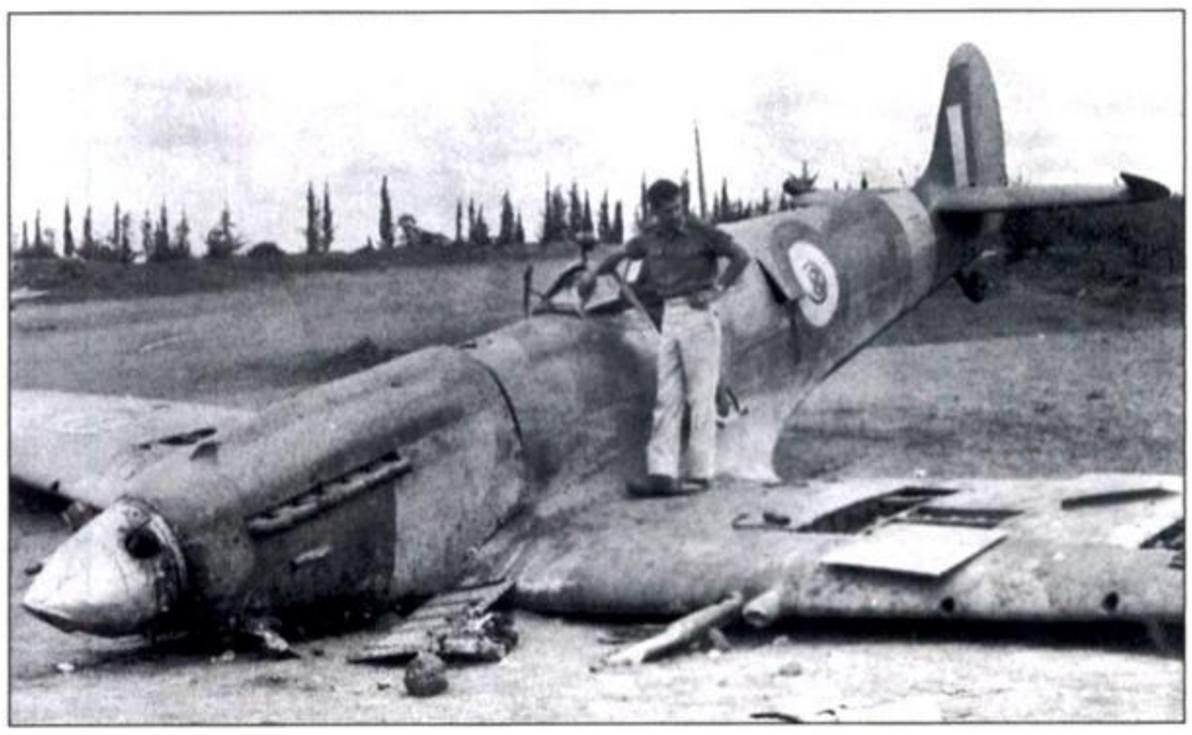
Mk IXEs were used as fighters and as trainers, serving until 1955. Denmark also used Mk IXs in the photo-reconnaissance role.

Egypt

Royal Egyptian Air Force

One squadron of Spitfire Mk VCs (15 aircraft) was received by the Royal Egyptian Air Force before the war's end and Mk IXs were delivered from surplus RAF stocks after the war. In total, 62 Merlin Spitfires were operated by the REAF, comprising 20 Mk Vs, 41 Mk IXs and one Tr.Mk IX. In the opening battles of the Israeli War of Independence, Egyptian Spitfires fought RAF Spitfire Mk XVIIIs over Ramat David. During the war REAF Spitfires undertook many ground attack sorties. One shot-down example was recovered by the Israelis and put into service with the IDF/AF. Egyptian Spitfire operators included No. 2 Sqn at El Arish, with Mk IXs.

This No. 2 Sqn Mk IX crash-landed on 5 November 1948 and was stripped by Israeli technicians. Several more fell to Israeli Spitfires and Avia S.199s.



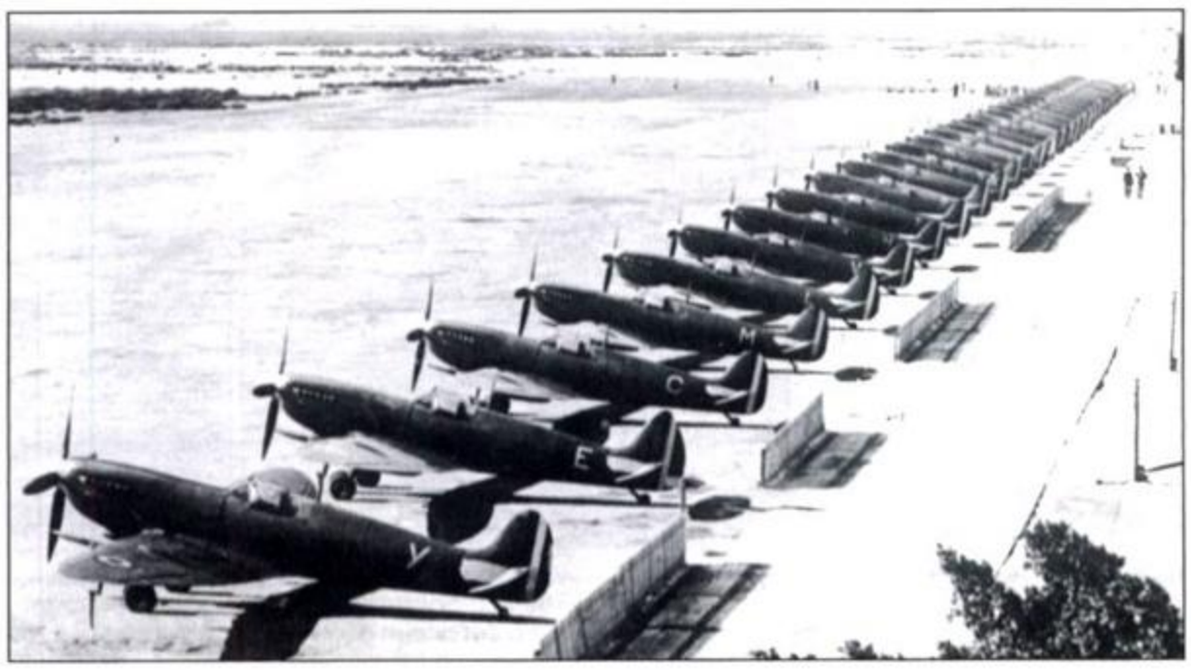
France

Armée de l'Air

One Spitfire Mk I was delivered to France before the war and evaluated by the Armée de l'Air. In 1941, the first Free French Spitfire Squadron (No. 340) was formed in the UK, followed by Nos 341 and 345. Each of these units was briefly part of the Allied occupation forces in Germany before being transferred to the Armée de l'Air in November 1945 as Groupes de Chasse IV/2, II/2 and II/2, respectively. Nos 326, 327 and 328 Squadrons were formed in Corsica in December 1943 and No. 329 at Ayr in January 1944, transferring to the Armée de l'Air in November 1945 as GC II/7, GC I/3, GC I/7 and GC I/2, respectively.

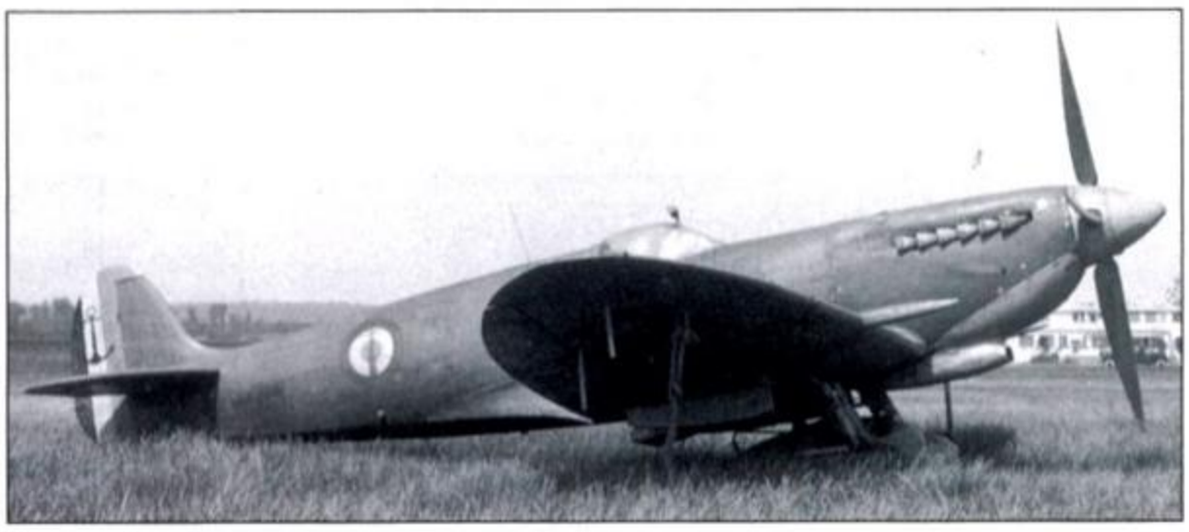
With increasing attacks on French forces in Indochina in late 1946, GC II/7 was established at Tan Son Nhut with Spitfire VIIIs borrowed from the RAF. They were replaced by a delivery of Mk IXs of GC I/7 in January 1947, bringing the total strength to 30 aircraft. The Spitfires served on ground attack duties in the theatre until November 1950.

The Aéronavale also used 20 Mk IXs as trainers for Seafire pilots at Cuers.



Above: Mk IXs of GC I/3 'Navarre' and GC II/3 'Champagne' line up at Nha Trang in 1950. Spitfires left Indo-China in November.

Below: Aéronavale Seafires are well-remembered, but the service also used 20 Spitfire Mk IXs as land-based trainers.



Merlin Spitfire Operators

Greece

Royal Hellenic Air Force

The Spitfire Mk VBs and VCs flown by the Greek-manned Nos 335 and 336 Squadrons, RAF were integrated into the Greek Air Force upon their return to Greece in late 1944. A total of 106 Mk Vs served, ultimately with the Advanced Training Squadron of the Scholi Icaron at Tatoi, as late as 1951. In 1947, 110 Spitfire LF and HF.Mk IXs were obtained by the reformed Royal Hellenic Air Force, mainly through the transfer of RAF aircraft already in the country. They were supplemented by 66 Mk XVIs in 1949. Aircraft of both marks were used against Communist targets in Athens and elsewhere during the 1948-49 campaign of the civil war. The active units were Nos 335, 336 and 337 Squadrons based at Hassani and Sedes. The last Greek Spitfires serving with the Scholi Icaron were retired in 1953. All Greek Spitfires retained RAF serials.

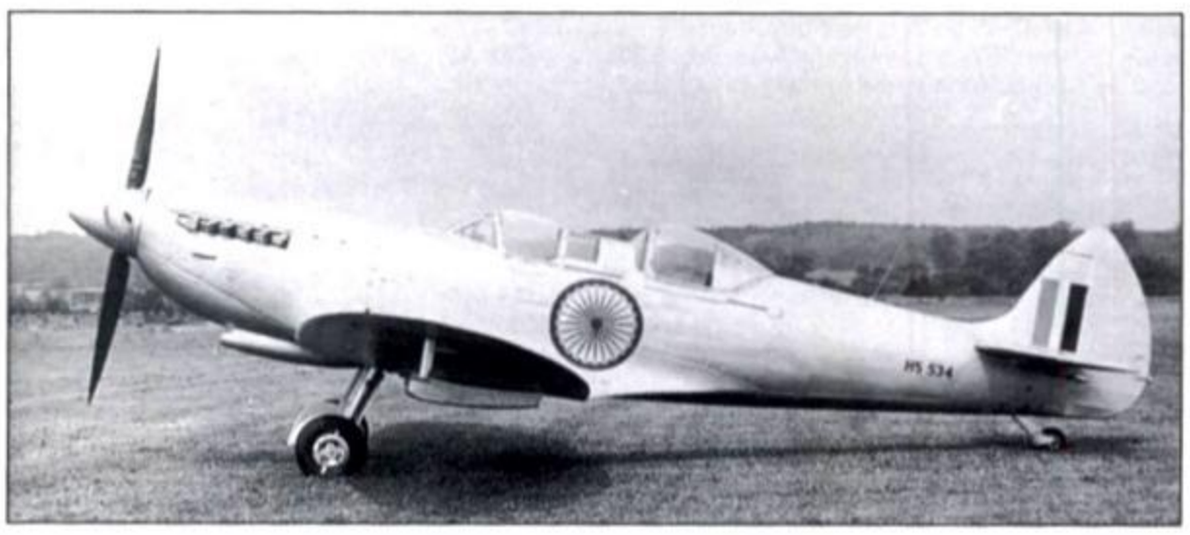
Greek Spitfires saw action during the civil war. Seen in 1949, this is a Mk XVI of No. 335 Squadron.

India

(Royal) Indian Air Force

Nos 4, 8, 9 and 10 Squadrons were all equipped with Spitfire Mk VIIIs by the end of the war, although the first two of these units had briefly operated the Mk VC. The aircraft were mainly employed in the fighter-bomber role, hampering the Japanese retreat. Griffon-engined marks had replaced the earlier aircraft in most units by the time of partition of the country in 1947, when most fighter units converted to the transport role, leaving only No. 2 Squadron with Spitfires. With growing tensions in the Kashmir region, Spitfires of various marks that had been left behind at Karachi docks by the RAF were uncrated and put into service. The Mk VIIIs were used for ground attack in Kashmir. Additionally, about a dozen Tr.Mk IXs were operated by the IAF from 1947 until the mid-1950s in the advanced/operational training role.

The Indian Air Force used the unarmed Mk IX for advanced training of future fighter pilots at Hakimpet.

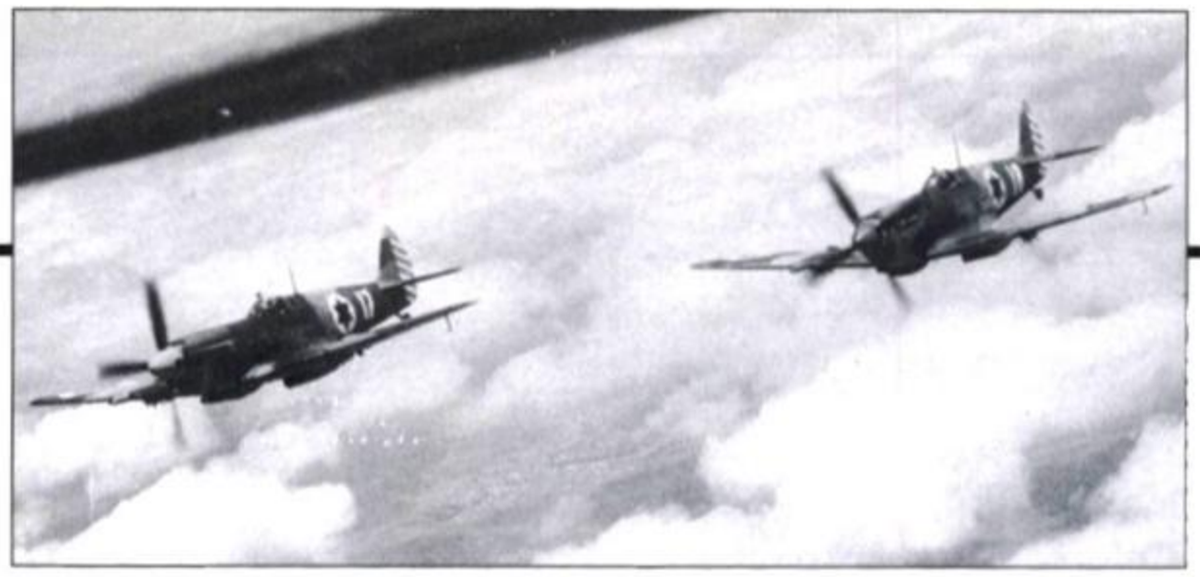


Ireland

Aer Chor na h-Eireann

In 1947 the Irish Air Corps replaced the Hurricane Mk IIs of No. 1 Fighter Squadron with 12 'de-navalised' Seafire LF.Mk IIIs. Six two-seat Spitfire T.Mk 9s (which had originally been built as LF.Mk IXs by Vickers-Armstrongs) were acquired for pilot training, all arriving on 5 June 1951. All had seen service with the RAF and several had recorded kills against the Luftwaffe. The aircraft (serials 158-163) were delivered in an overall pale green paint scheme, which was later replaced by a natural metal finish. The last operational aircraft was withdrawn from service in 1961, making Ireland probably the final military Spitfire operator in the world.

163 was the Irish Air Corps' last operational Spitfire. Of the six delivered one crashed but the other five are still flying, now as warbirds.



Israel

Heyl Ha'Avir

Approximately 59 Spitfires were bought from the Czechs during the 1948 war for $23,000 each, although the first two Israeli Spitfires were built from parts of scrapped RAF Mk IXs and a shot-down Egyptian aircraft. A number of the ex-Czech (and ex-RAF) aircraft were flown to Israel but the majority were shipped out. The main user was No. 101 Squadron, which saw much combat with the Spitfire. No. 105 Squadron was the main training unit, and No. 107 Squadron briefly used Spitfires. Another 30 Mk IXs were supplied from Italian surplus in 1953. The Spitfire was retired from IAF service in April 1956.

A pair of No. 101 Sqn Spitfire Mk IXs is seen in January 1949 during an escort mission for No. 69 Sqn B-17s operating over the Faluja pocket. Israeli Spitfires scored several notable successes over Egyptian and RAF aircraft, including the destruction of a four-ship flight of RAF Spitfire FR.Mk 18s and the routing of a follow-up flight of Tempest Mk VIs.

Italy

Aeronautica Cobelligerante del Sud/ Aeronautica Militare Italiana (AMI)

Following the Italian surrender, 53 RAF Spitfires (of which 33 were made airworthy) were transferred from RAF stocks to form the complement of 20° Gruppo, 51° Stormo. The unit became operational as part of the Co-Belligerent Air Force in October 1944. All but a few examples were withdrawn at the end of the European war. In June 1947, following the withdrawal of Allied forces, a large number of aircraft, including Spitfire IXs, were left behind, and they were taken on strength by the Aeronautica Militare Italiana (AMI). Some 145 of these aircraft received AMI serials, although initially the aircraft operated under their previous RAF identities. The last aircraft were retired from the 3° Gruppo Scuola Volo at Lecce in 1952.

This Mk V was one of the original 20° Gruppo aircraft (note the 51° Stormo badge of a black cat chasing three mice on the fin). This was the Co-Belligerent Spitfire unit, which later re-equipped with Mk IXs.

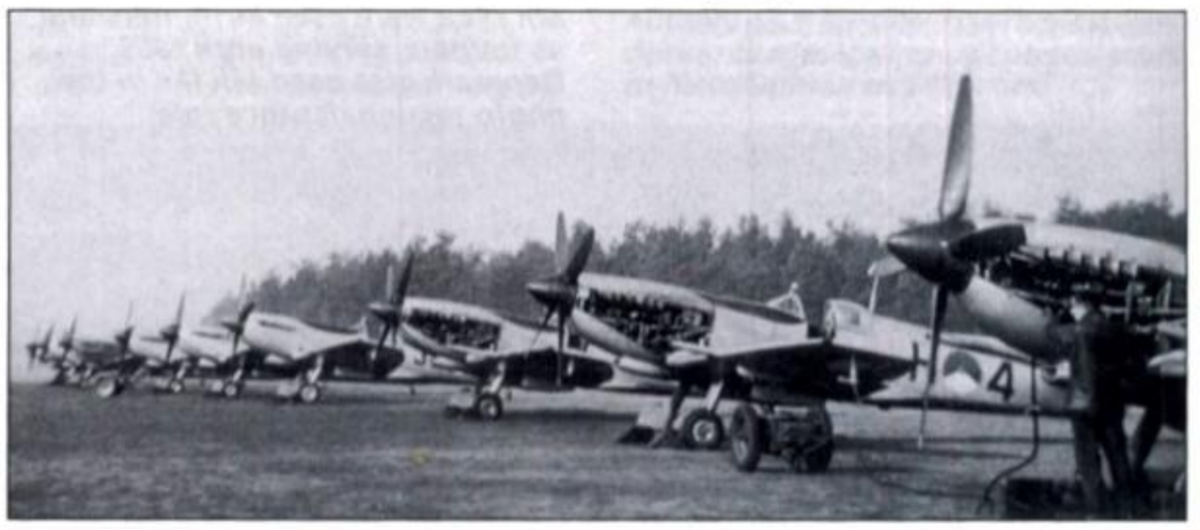
Netherlands

Luchtstridkrachten

No. 322 Sqn was formed in the RAF in June 1943 as the Dutch-manned fighter squadron, equipped with Spitfires. It was revived in the post-war Dutch air force, which did not gain autonomy from the army until 1953. Over 100 Mk VBs, XVICs and XIVEs, and 55 Mk IXs, were delivered between 1946 and 1948, with an additional three Tr.Mk IX two-seaters arriving during 1948. These aircraft equipped No. 322 Squadron, which was working up for transfer to the Far East. The aircraft were transferred to the JachtVlieg School (JVS) when the squadron ground echelon shipped out. A batch of 20 Mk IXs was delivered from RAF stocks directly to No. 322 Squadron based at Kalidjati in Indonesia in 1947, where they were used on ground attack missions against nationalist insurgents. The squadron reacquired its original aircraft on return to Twenthe in late 1949. In 1950, the 18 survivors of the East Indies force were returned to the Netherlands, and 15 were transferred to Belgium. The last Spitfires were withdrawn in 1954.

The homebased aircraft were serialled in the H-1 to H-35 range and the Far East aircraft H-101 to H-120, the survivors being reserialled H-50 to H-69.

Spitfire Mk IXs of No. 322 Squadron are seen at Twenthe in 1951. Earlier the squadron had used borrowed RAF Spitfires on counter-insurgency work in Indonesia.



Norway

Kongelige Norske Flyvapen

The two Norwegian Spitfire squadrons in the RAF, Nos 331 and 332, were transferred to the Royal Norwegian Air Force in November 1945. In 1947 Norway purchased a large package of defence equipment from Britain, including 47 Spitfire Mk IXs and three PR.Mk XIs. The Spitfires, which were well-worn ex-RAF examples, served with 331 and 332 Skvadron at Gardermoen, Vaernes and Bardufoss. In total, 74 Spitfires served with the RNoAF. Twenty-five were lost in accidents before the type was retired in 1954. RAF serials were retained for at least the first part of their service.

Norwegian squadrons used RAF-style two-letter codes. This LF.Mk IXE wears the 'CI' of No. 331 Sqn.

Portugal

Aeronautica Militar/ Força Aérea Portuguesa

The Portuguese had ordered 15 Spitfire Mk Is prior to the outbreak of war but delivery was cancelled following the German assault of May 1940. In 1942, 18 Mk IAs were delivered, these aircraft forming Esc. XZ at Tancos (Base Aérea 3), then moving to BA 2 (Ota). Under the Azores Agreement, the British government agreed to supply 34 Mk Vs delivered from October 1943, these becoming operational at Ota with Escuadrilhas MR and RL. Some of the VBs went to Esc. ZE at BA 2 (serving alongside Blenheims). An additional 60 Mk Vs were delivered in 1947-48. In January 1951, the surviving VBs were concentrated into Escuadrãos 20 and 21. Both units had given up the Spitfire some time before they were reformed with F-84Gs in late 1952/early 1953.

Spitfire Mk Vs from Escuadrilhas XZ, RL and MR are seen at Ota.

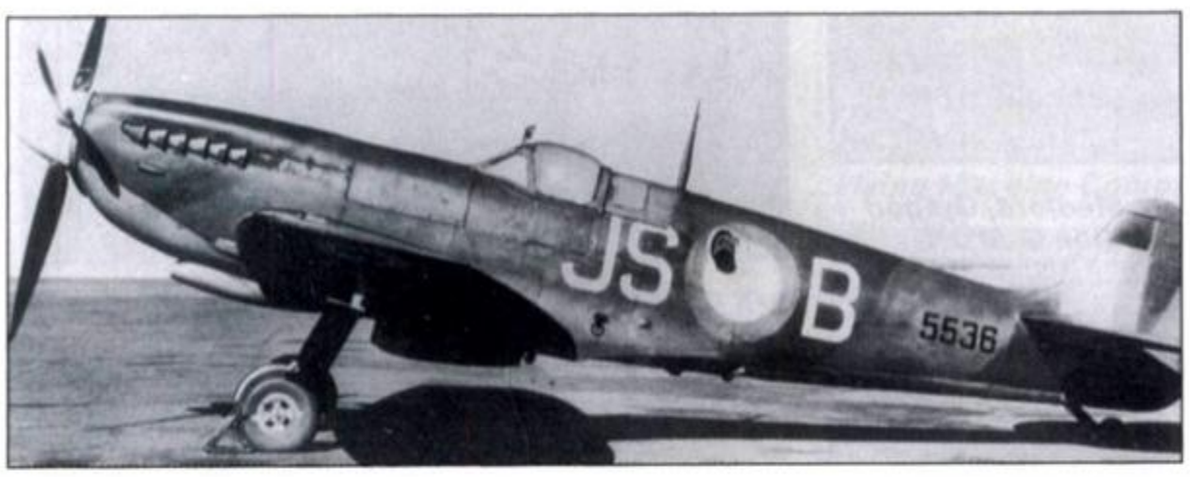
South Africa

South African Air Force

Nos 1, 2, 3, 4, 7, 9, 10, 11, 40 and 41 Squadrons, SAAF flew Spitfires Vs and IXs as part of the Desert Air Force in North Africa and Italy. No. 1 Squadron also flew Mk VIIIs and No. 40 some PR.Mk XIs. No. 11 Squadron re-equipped too late to see action with Spitfires. These aircraft remained on RAF charge and had RAF serials. After the war, Nos 1, 2 and 4 Squadrons were reformed in South Africa as the Fighter Wing at Waterkloof, using 136 Mk IXs donated by the British government. No. 60 Squadron also used Spitfires for reconnaissance and other roles. No. 2 Squadron personnel trained on Spitfires of the Bombing, Gunnery and Air Navigation School before going to Korea to fly P-51s in 1950. The Spitfires of the Fighter Wing were replaced from 1952 by Vampires.

Spitfires in South Africa carried a four-digit serial in the 5000 range.

This No. 60 Sqn Mk IX has an oblique camera fitted for the reconnaissance role.



Turkey

Türk Hava Kuvvetleri

Turkey received a pair of Spitfire Mk Is from an order for 15 in 1940. During the war, 84 tropicalised Mk VBs and VCs followed, equipping two Boluks (Companies) of the 6nci Alay (Regiment) at Gaziemir, four Boluks of the 7nci Alay at Kutahya and one Boluk of the 8nci at Erzincan. After the war, Turkey received a substantial amount of British war-surplus equipment including 207 Spitfires, 203 Mk IXs and four PR.Mk XIXs. Users of the Mk IX included the 7nci Alay (four Boluks), the 6nci Alay (two Boluks), and the 4nci Alay (four Boluks). In 1951, the Turkish Air Force was re-established along Western lines and the basic unit became the Filo (Squadron). Filos that operated Spitfire IXs until the last were retired and scrapped in 1954 included Nos 141-143, 161-163, and 171-173.

This group of Turkish Spitfires includes Mk Vs and Mk IXs.

USSR

Voenno Vozdushnyye Sily

The Soviet Union took delivery of 1,188 Spitfire Mk IXs, 143 Mk Vs and two PR.Mk IVs from early 1943, most of them delivered through Iran. Many were rebuilt and reserialled ex-RAF aircraft. A number were converted in Russia into two-seat trainers with a locally-designed rear canopy. It is possible that a small number were transferred to China.

This is one of the 143 Mk Vs delivered to the VVS in April 1943. The aircraft has the locally fitted RPK 10M loop antenna.

United States

United States Army Air Forces

The three 'Eagle' squadrons of the RAF (Nos 71, 121 and 133) were equipped with Spitfire VBs at the time they were transferred to USAAF control in October 1942 as the 334th, 335th and 336th Pursuit Squadrons of the 4th FG respectively. The Spitfires were replaced by P-47s in March 1943, but another 600 aircraft had become available under 'reverse Lend-Lease' and began to equip two groups of the Eighth Air Force (the 31st and 52nd FGs) in mid-1942. These units transferred to the 12th Air Force to take part in Operation Torch in November 1942, later equipping with Mk IXs and some VIIIs. Other Spitfire units within the 8th Air Force included the 350th FG (for training only), and the 67th Observation Group, both initially with Mk Vs, and the 14th Photo Squadron with PR.Mk XIs.

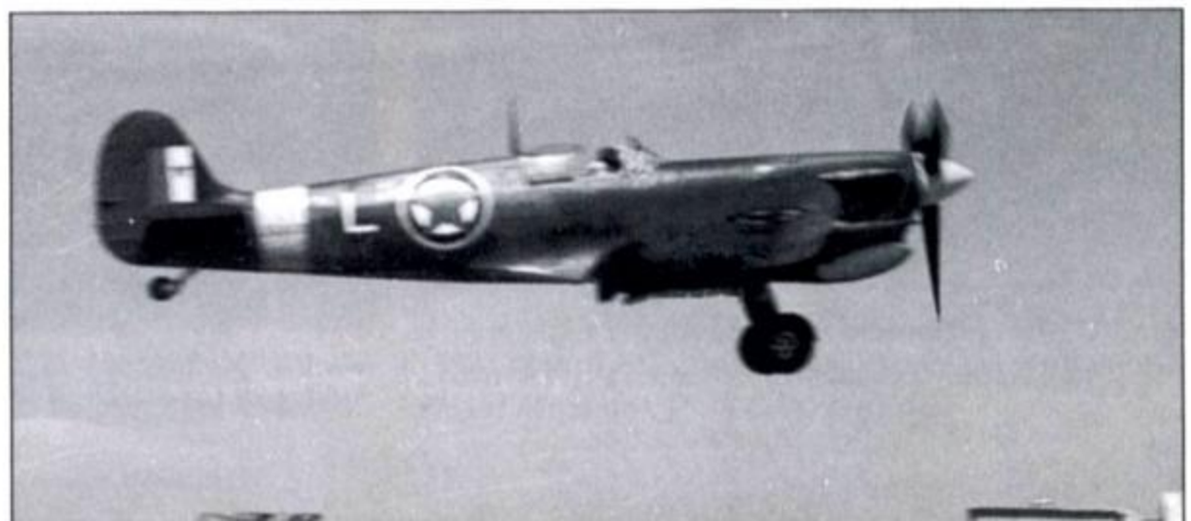
A Spitfire Mk V of either the 31st or 52nd FG is seen in England prior to its move to North Africa.

Yugoslavia

Jugoslovensko Ratno Vazduhoplovstvo

No. 352 Squadron, a Yugoslav-manned Spitfire squadron operating as part of the Tactical Wing of the Balkan Air Force, became operational in August 1944, flying ground-attack and bomber escort missions. The squadron's aircraft wore Yugoslav insignia with RAF serials. The squadron was disbanded as an RAF unit on 15 June 1945 and became part of the Yugoslav Air Force. Eighteen Mk Vs and three Mk IXs served with the JRV until August 1952. The aircraft were serialled 9476-9503.

Complete with Yugoslav national markings, this tropicalised Mk VC served with the RAF's No. 352 Sqn, which was manned by Yugoslavs and later formed the basis of the reborn JRV.



Flying Survivors

Over 20,000 Spitfires of all variants were built between 1936 and 1948. Of these, over 200 survive, 40-50 in airworthy condition. Merlin-powered examples totalled 38 at the time of writing, a surprising number having seen wartime service. A few are notable for having flown in successful combats during World War II. All are shown here, with their serial numbers, owners/operators and locations.

Mk IA AR213: Blue Max Museum of Film Flying, Booker, UK (the only airworthy Mk I)

Mk IIA P7350: Battle of Britain Memorial Flight, RAF Coningsby, UK (oldest flying Spitfire)

Mk VB AB910: Battle of Britain Memorial Flight, RAF Coningsby (in No. 71 'Eagle' Squadron markings for USAF 50th anniversary)

Mk VC AR501: Shuttleworth Trust, Old Warden, UK (in the markings of No. 310 (Czech) Sqn)

Mk VC AR614: Restored for the Alpine Fighter Collection, NZ. Based at Duxford, UK in late 1997

Mk VC BM597: Historic Aircraft Collection, Audley End, UK (in the markings of No. 317 (Polish) Sqn)

Mk VB EP120: The Fighter Collection, Duxford, UK (another aircraft with wartime 'kills')

Mk VIII MT719: Cavanaugh Flight Museum, Dallas, Texas (in SEAC markings)

T.Mk 8 MT818: John Erickson, Medford, Oregon (when carrying its civil registration G-AIDN)

Mk VIII MV154 (marked as MT928 of No. 145 Squadron, RAF): Robs Lamplough, Filton, UK

Mk VIII MV239/A58-758: Colin Pay, Scone, NSW, Australia (in wartime RAAF markings)

Mk VIII NH631: Indian Air Force Historic Flight, Palam, New Delhi

Mk IXE MA793: David Price, Museum of Flight, California (the only airworthy ex-USAAF Spitfire)

Mk IXC MH434: Old Flying Machine Company, Duxford, UK (an aircraft with 'kills' to its name)

T.Mk 9 MJ627: Maurice and Peter Bayliss, Coventry airport (an ex-Irish Air Corps aircraft)

Mk IXE MJ730: David Pennell, Staverton aerodrome, UK

T.Mk 9 MJ772: Champlin Fighter Museum, Mesa, Arizona (with rear cockpit faired over)

Mk IXC MK732: Dutch Spitfire Flight, Deelen/Gilze-Rijen Air Base, Netherlands

Mk IX MK923: Cliff Robertson, Kalamazoo Air Zoo, Michigan (in the markings of No. 126 Sqn, RAF)

T.Mk 9 ML407: Carolyn Grace, Duxford, UK (as a single-seater, the first Allied fighter to shoot down an enemy aircraft on D-Day, flown by New Zealander Flt Lt Johnnie Houlton)

Mk IXC ML417: The Fighter Collection, Duxford, UK (first Allied aircraft in France after D-Day)

Mk IXE NH238: Warbirds of Great Britain estate, Florida (a former COGEA target tug)

T.Mk 9 PT462: Bill Goldstein, Lakeland, Florida (converted to two-seater in mid-1980s)

T.Mk 9 PV202: Rick Roberts, Goodwood, UK (an ex-Irish Air Corps two-seater with wartime 'kills')

Mk IXE TE213: South African Air Force Museum Historic Flight (serialled 5553, with Atlas Cheetah)

T.Mk 9 TE308: Bill Greenwood, Aspen, Colorado (one of the Battle of Britain film fleet)

Mk IXE TE554: Israeli Air Force Museum, Be'er Sheva Air Base (ex-Czech air force)

Mk IXE TE566: Historic Aircraft Collection, Duxford, UK

PR.Mk XI PL965: Chris Horsley (operated by Old Flying Machine Company), Duxford, UK

PR.Mk XI PL983: Warbirds of Great Britain estate, Florida (here in company with MH434)

Mk XVIE RW382: Bernie Jackson, San Jose, California (another Battle of Britain film veteran).

Mk XVIE SL721: Woodson K. Woods, Scottsdale Arizona (one of the last RAF Spitfires, in use 1951)

Mk XVIE TB863: Alpine Fighter Collection, Wanaka, NZ (the only airworthy Spitfire in NZ)

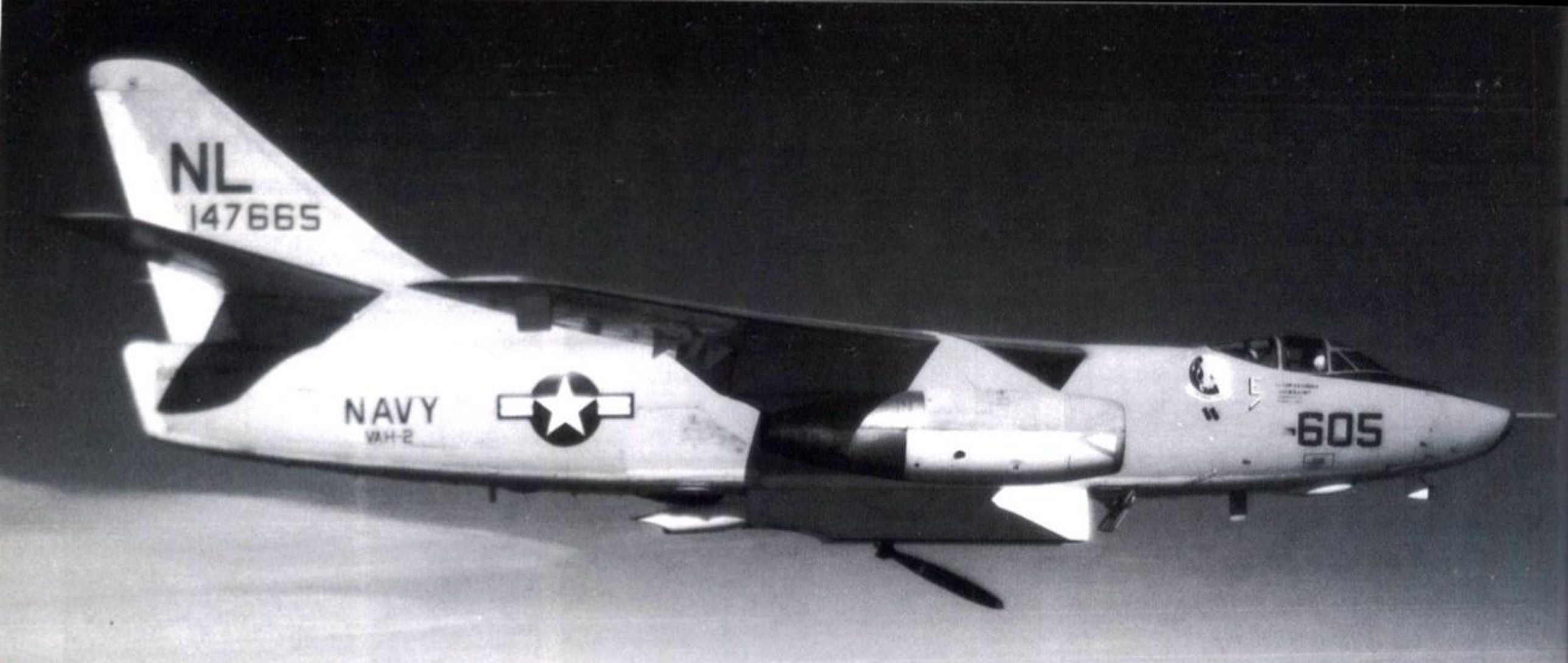
Mk XVIE TD248: Eddie Coventry/BAC Aviation, East Colne (in the markings of an RAF Mk XIV)

Mk XVIE TE184: (built with a bubble canopy but converted to 'high back' standard)

Mk XVIE TE356: Delford M. Smith/Evergreen Heritage Collection, Marana, Arizona

Mk XVIE TE384: Hockey Treloar Syndicate, Toowoomba, Queensland, Australia

LF.Mk XVIE TE476: Kermit Weeks/Fantasy of Flight Museum, Polk City, Florida



Air War Vietnam

'Heavy Two'

Bomber Skywarriors in Vietnam

High over the North Vietnamese coast, an A-3B of VAH-2 releases a slick GP bomb. The Skywarrior was really too vulnerable for this kind of mission and was soon assigned to the tanker role as the conflict escalated.

Inset right: The original (1956-60) badge of HATRON TWO was the flying rhino. The rampant lion badge was used until the squadron became VAQ-132 in 1968.

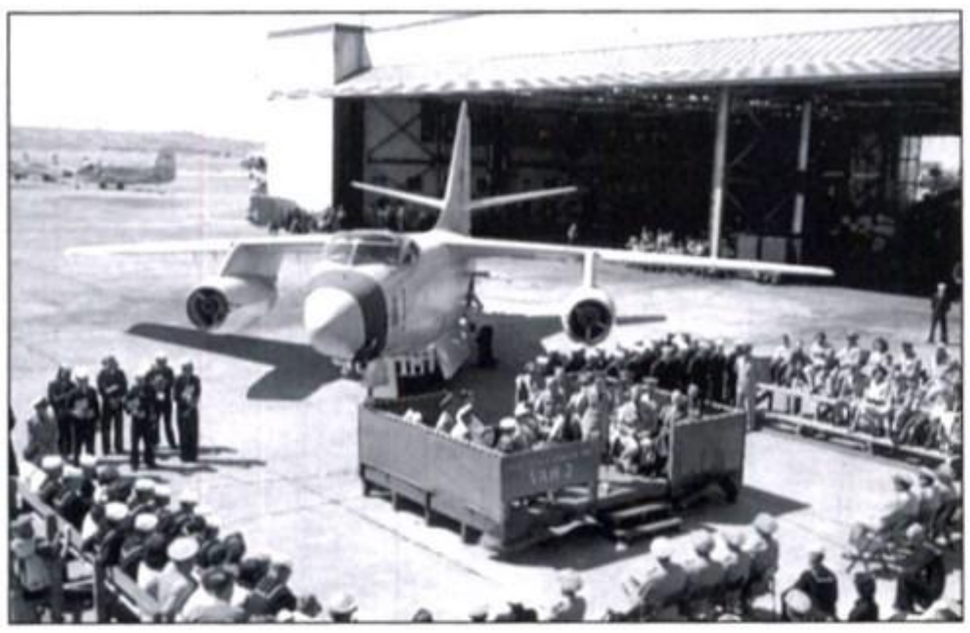
Douglas's A3D Skywarrior was built for strategic nuclear bombing of Russia, but its only combat action was in Southeast Asia where conventional ordnance was expended against tactical targets. More importantly, the 'Whale' proved adaptable to other roles, including air refuelling and electronic warfare. VAH-2 'Royal Rampants' was the first A3D unit to drop bombs in action, and excelled in its other roles.

The first of VAH-2's A3D-1s, BuNo. 135440, was flown from El Segundo to NAS North Island on 30 April 1956 by the squadron skipper (Cdr Art Irish, second from right), the XO (Cdr Bolton, fourth from left) and Chief Thornhill (sixth from right). The manufacturer was represented at the handover by the chief designer, Ed Heinemann (far left) and Donald Douglas Jr (centre).

Douglas's A3D/A-3 Skywarrior, forever to be known as the 'Whale', had its origins in a 1948 Request For Proposals for a long-range carrier-based heavy attack aircraft to be powered by jet engines, which would be capable of delivering a nuclear bomb. Fourteen manufacturers were invited to submit proposals to the Bureau of Aeronautics (BuAer.) for the XVA(H1) competition, of which eight did so. After reviewing the proposals for this demanding requirement, BuAer invited two of the companies, Curtiss and Douglas, to submit more detailed design proposals and cost studies for completion of two flying and one static test airframes. The Douglas design team at El Segundo, led by Edward Heinemann, was able to keep the gross weight of its Model 593-8 design below the 100,000-lb (45359-kg) estimate of the Navy, and thus had little difficulty edging out the substantially heavier Curtiss design. The contract for the three test airframes under the BuAer. designation of XA3D-1 was awarded in July 1949.

Problems with the Navy-selected Westinghouse XJ40-WE-3 engines, and a structural failure on the static-test airframe which necessitated some redesign, delayed the first flight of the XA3D-1 prototype from the proposed date of August 1951 until October 1952. In the interim, the Navy had fortunately decided to install 9,500-lb (42.3-kN) thrust Pratt & Whitney J57-P-1 engines into production A3Ds in place of the 7,500-lb (33.4-kN) J40-WE-12. The first of these production aircraft (ordered before the XA3D-1's maiden flight) flew on 16 September 1953. The Navy test and evaluation programme lasted from 1953 until 1957 with carrier suitability trials on a '27-C' (modified 'Essex'-class) ship conducted in June 1956.

While these tests were underway, plans to place the Skywarrior in service were initiated. The first two Heavy



VAH-2's first aircraft served as a backdrop for a welcoming ceremony at North Island, attended by squadron personnel and family. At this time, the aircraft wore 'BF' codes. The squadron was temporarily based at North Island during the introduction period of the Skywarrior.

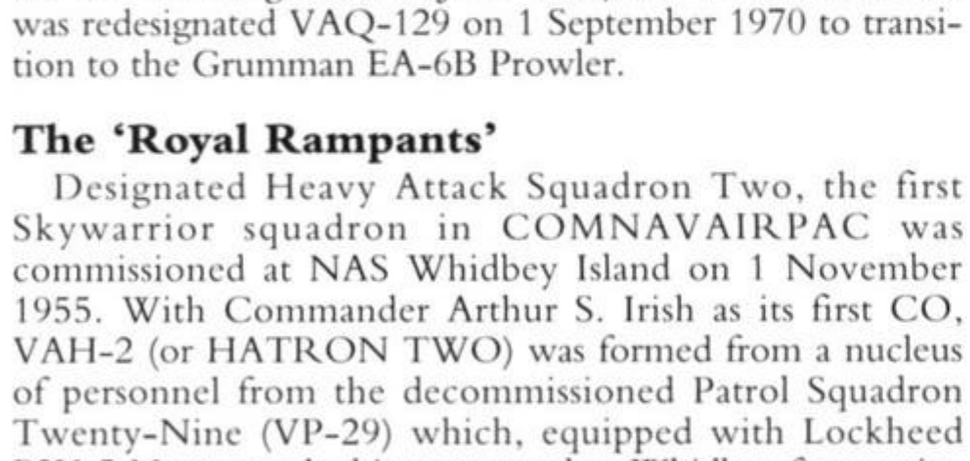
Attack Squadrons – VAH-1 with LANTFLT (Atlantic Fleet) and VAH-2 with PACFLT (Pacific Fleet) – were commissioned on 1 November 1955 at NAS Jacksonville, Florida, and NAS Whidbey Island, Washington, respectively. VAH-1 got its first A3D-1s on 31 March 1956 and VAH-2 received its first A3D-1 at the end of the following month. Eventually, in the type's design role (nuclear strike), A3D-2s went on to equip 11 additional Heavy Attack Squadrons (HATRONs). With LANTFLT, VAH-1, VAH-3, VAH-5, VAH-7, VAH-9, VAH-11, and VAH-13 served as deployable squadrons, while VAH-2, VAH-4, VAH-6, VAH-8, and VAH-10 were the PACFLT-deployable HATRONs. Two other HATRONS, VAH-3 and VAH-123, served as Replacement Air Group (RAG) training units. The last deployable squadrons to fly KA-3Bs (the A3D designation was changed to A-3 in September 1962 and tanker-configured aircraft were given the KA-3B designation in June 1967) was VAH-10, which was redesignated VAQ-129 on 1 September 1970 to transition to the Grumman EA-6B Prowler.

The 'Royal Rampants'

Designated Heavy Attack Squadron Two, the first Skywarrior squadron in COMNAVAIRPAC was commissioned at NAS Whidbey Island on 1 November 1955. With Commander Arthur S. Irish as its first CO, VAH-2 (or HATRON TWO) was formed from a nucleus of personnel from the decommissioned Patrol Squadron Twenty-Nine (VP-29) which, equipped with Lockheed P2V-5 Neptunes, had just returned to Whidbey from a six-month WestPac deployment to Naha, Okinawa. (VP-29 had itself been commissioned on 27 August 1952 with personnel and P2V-2s from VP-812, a Reserve unit which was decommissioned on that date after 25 months on active duty.) Additional personnel were quickly added to VAH-2, but virtually all of the initially assigned pilots were qualified only in reciprocating engines and had to be sent to the Jet Transition Training Unit at NAS Olathe, Kansas. While pilots were learning the peculiarities of jet flying at the JTTU, the remaining VAH-2 'plankholders' made the move to NAS North Island, California, where the squadron was to train for its assigned mission of nuclear strike with carrier-based A3Ds. Pending delivery of its A3D-1s (and later A3D-2s), VAH-2 was equipped with a few Lockheed P2V-3Bs (fitted with the ASB-1 bombing system of the Skywarrior) for training bombardier-navigators, Lockheed P2V-5s on which pilots could stay proficient in flying heavy aircraft, and Lockheed TV-2s (the Navy version of the T-33A) for jet training. In addition, HATRON TWO later borrowed Douglas F3D-2Ts from FAWTUPAC (Fighter All-Weather Training Unit Pacific) for carquals.

In February 1956 Commander Irish and four crews arrived at NAS Patuxent River, Maryland, to join crews from VAH-1 (the first LANTFLT Skywarrior squadron) to participate in the A3D Fleet Indoctrination Program. Aimed at evaluating the A3D-1 and its systems to determine readiness for fleet delivery, the FIP was scheduled to be completed in March 1956 after seven aircraft accumulated a total of 700 flight hours. During FIP, crews – consisting of pilot, assistant pilot-bombardier, and gunner-navigator – also logged many hours in briefings and in mobile trainers (rather crude forebears of today's simulators). Later, as the A3D only had one set of controls, crew composition was changed to pilot and bombardier-navigators (both of whom were commissioned officers) and an enlisted man performing the duties of dead reckoning and celestial navigation, plane captain, and maintenance man.

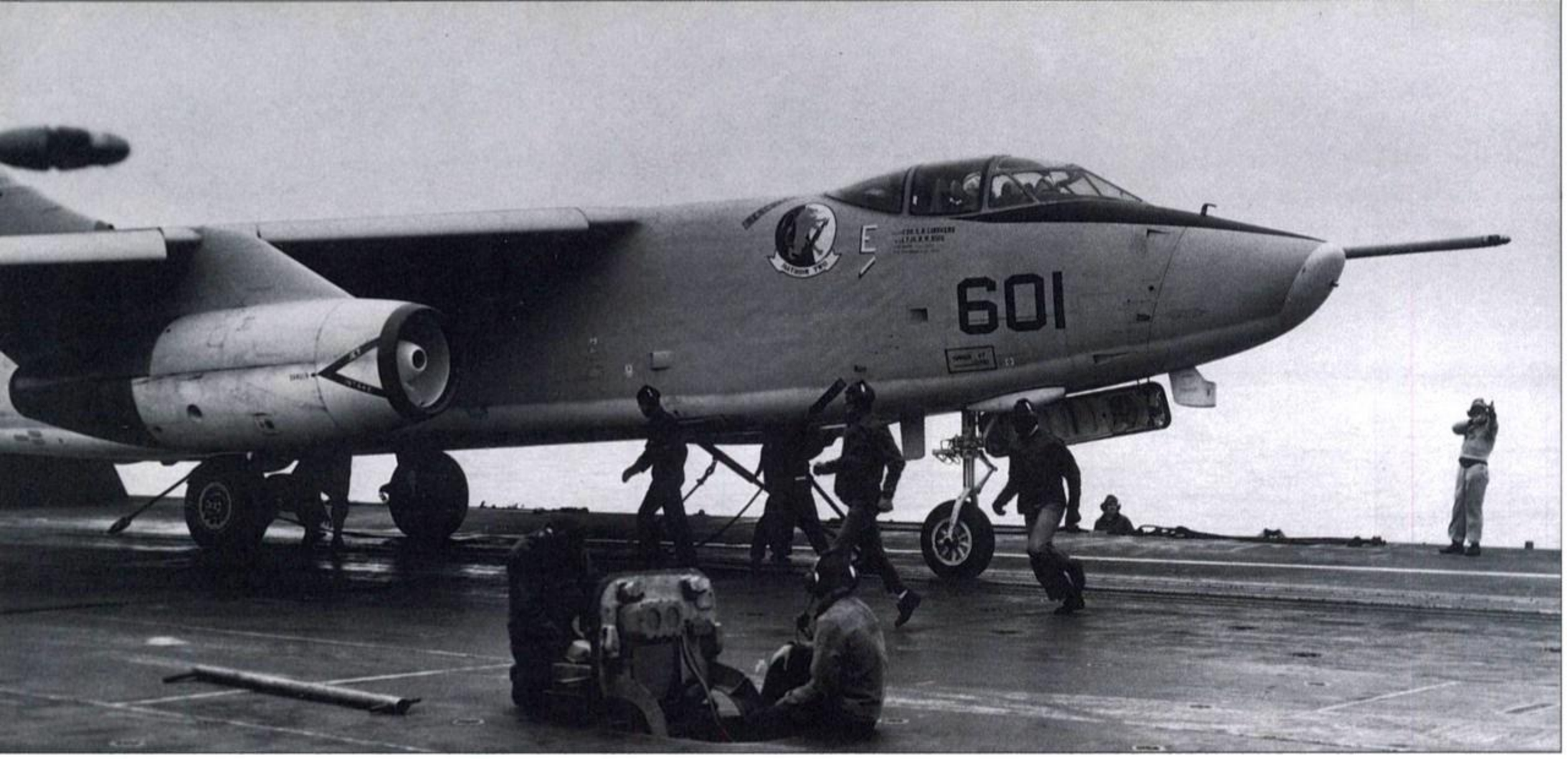
Following completion of FIP and delivery of the first



When two 'Whales' were positioned on the catapult of a '27-Charlie' carrier such as USS* Ticonderoga*, the wings overlapped, dictating that the starboard 'cat' always be fired first. The 20-mm M3L cannon and Aero 21B turret seen here were later replaced by a defensive ECM (DECM) system.

Below left: BuNo. 138908 was the third Skywarrior lost by VAH-2 when it crashed on launch from USS* Ticonderoga *during operations in the South China Sea, January 1958.

Below: Seen sharing the deck of* Ticonderoga *with an earlier generation of Douglas bomber are two A3D-2s of Det Mike. This was the first HATRON TWO WestPac cruise, 1957-58.



During pre-deployment work ups on* Coral Sea *on 2 October 1964, VAH-2 had the privilege of flying Vice Admiral James D. 'Jig Dog' Ramage in the right seat of the skipper's aircraft. Ramage had previously been the commander of Heavy Attack Wing One, parent of the A3D and AJ Savage squadrons.

five A3D-1s to VAH-1 on 31 March 1956, VAH-2 personnel and their skipper returned to San Diego and NAS North Island. Finally, on 30 April 1956, Commander A. S. Irish, Lieutenant Commander T. Bolton, and ADC G. L. Thornhill flew BuNo. 135440, the 48th Skywarrior built by Douglas, from the El Segundo plant to NAS North Island. Bearing the tailcode 'BF', as initially assigned to VAH-2, the modex 1, and the charging rhino insignia first adopted by the squadron, BuNo. 135440 was received at the naval air station in San Diego with all appropriate 'pomp and circumstance'.

While A3D training was underway, the ex-patrol aircraft pilots had to become carrier qualified. Accordingly, F3D-2Ts were used in June 1957 for carrier qualification aboard the USS *Wasp* (CVS-18) off the coast of sunny California. Now fully 'carqualled', a first group of VAH-2 pilots was ready for the big day: hitting the boat (the USS *Bon Homme Richard*, CVA-31) with their Skywarriors (by then VAH-2 had disposed of its A3D-1s). With the A3D-2s loaded aboard 'Bonnie Dick' on 10 May 1957, VAH-2 set out for two weeks of carquals. Operations were briefly called off after the XO and his crew were killed in the crash of BuNo. 138919, and a more fortunate crew survived after hitting the ramp during the first week of carquals. Quickly, however, VAH-2 crews overcame grief and difficulties to become the first to qualify aboard a small deck carrier.

In the process, Commander Herbert L. Salyer, who had relieved Commander Irish in February 1957 as skipper of VAH-2, gained the distinction of making the first Skywarrior carrier day-landing aboard a '27-Charlie' (i.e., an upgraded 'Essex'-class carrier with an angled deck) on 24 May 1957. That same night, Lieutenant Edward D. Mitchell became the first pilot to be night-qualified aboard an SCB '27-C' carrier. Later selected as an Apollo astronaut, Mitchell was aboard the lunar module LM-8 *Antares* for the third moon landing in February 1971. (Records are somewhat confused: some VAH-2 documents indicate that Mitchell was the first 'day' qualified pilot and Salyer the first to 'night' qualify. Aviation history is not a formal science!) After completing initial carquals, VAH-2 was ready for 'the real world': the first WestPac deployment and first operational cruise aboard a '27-C' carrier for the Skywarrior.

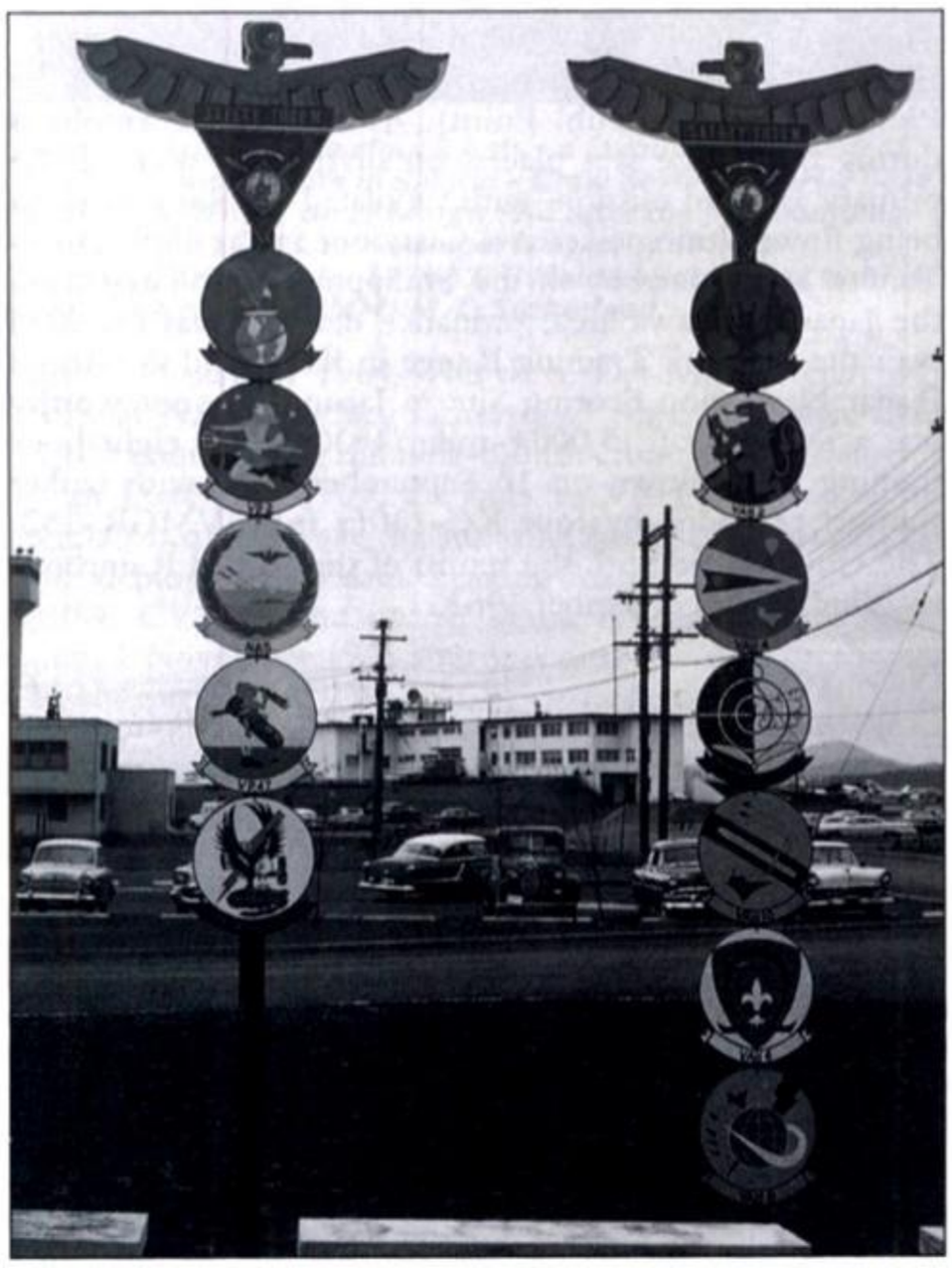
The first cruises

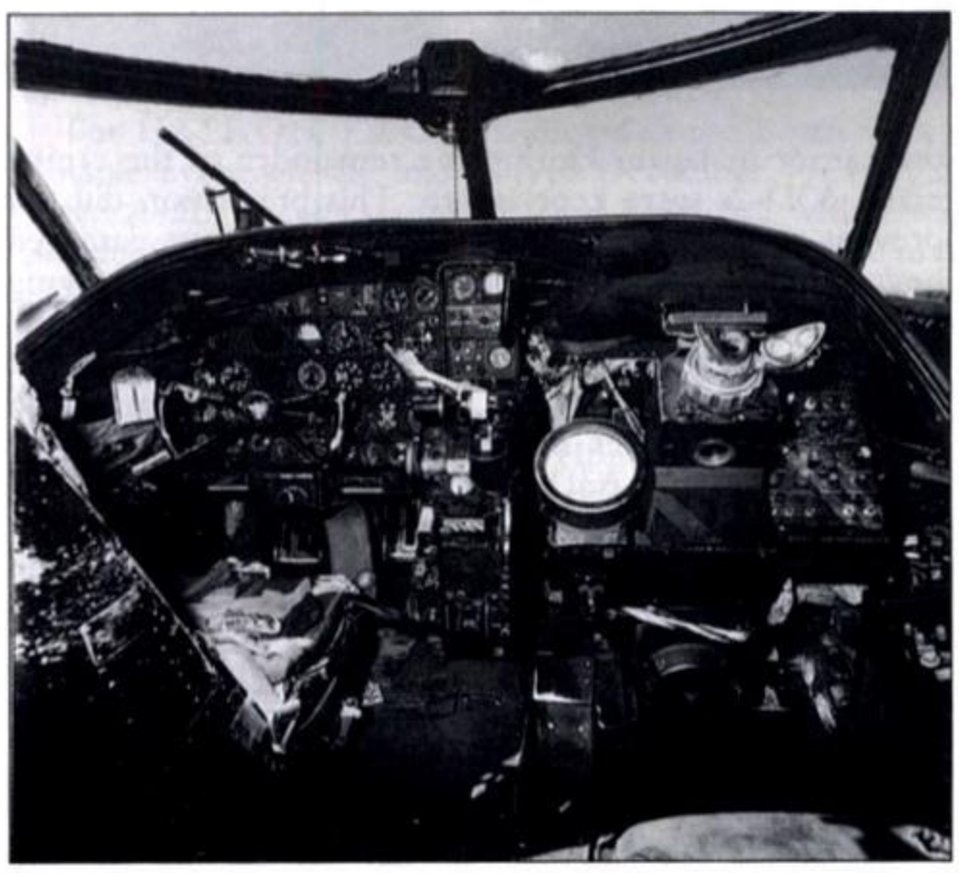
After VAH-2 had been split into detachments to operate aboard small carriers – PACFLT had not yet gained its first super carrier, the USS *Ranger* (CVA-61) – Detachment Bravo deployed aboard *Bon Homme Richard* on 12 July 1957, with Lieutenant Commander Baumgardner as OIC. The remainder of the squadron 'transpaced' from NAS Moffett Field to NAS Barbers Point, setting a new record of 4 hours 2 minutes between California and Hawaii (airlines were then flying piston-engined aircraft to what was still the Territory of Hawaii). After the carrier and its CVG-15 had completed ORI (Operational Readiness Inspection) at sea – with Det Bravo earning Outstanding grades – the other VAH-2 crews carqualled off Hawaii. Another detachment, Det Mike under OIC Commander Hine, 'transpaced' back to embark aboard the USS *Ticonderoga* (CVA-14) on 16 September 1957. Thereafter, the bulk of the squadron, now designated Det X-Ray, proceeded to NAS Cubi Point in the Philippines to support the two carrier-based dets. In September 1957, Det X-Ray lost BuNo. 138936 and its crew during operations off Cubi.

While Det Mike was still aboard *Ticonderoga* and part of Det X-Ray remained at Cubi Point, Commander Salyer and Det Mike returned to NAS North Island on 12 December 1957. Sixteen days later, VAH-2's homeport was transferred from California to Washington. The squadron remained homeported at NAS Whidbey Island until reorganised as VAQ-132 11 years later. With VAH-2 staff at Whidbey, Det X-Ray 'transpaced' its remaining A3D-2s from Cubi Point in March 1958 while Det Mike completed its first 'Tico' deployment on 25 April (after losing BuNo. 138908 and crew in a January 1958 launch accident in the South China Sea).

Barely back at home, some VAH-2 members returned to sea as a result of rising international tensions following the US intervention in Lebanon in July 1958. VAH-2 Det Hotel, which had been scheduled to deploy aboard *Ticonderoga* in August, received 12-hour notice to 'transpac' to Cubi Point. After operating ashore for a few weeks, Det

Seen during preparations for what became* HATRON TWO*'s first combat cruise are 'Whales' from VAH-2 and the Replacement Air Group, VAH-123. The two 'Rampants' aircraft following the Dayglo-tailed RAG birds are a 'ZA'-coded tanker and an uncoded A-3B in bomber configuration.





Above: The handling qualities of the 'Whale' at low speed around the 'boat' were best described as 'sporty'. Here a VAH-2 A3D-2 gets a wave-off from Coral Sea in January 1961. Under the September 1962 tri-service redesignation, the A3D-2 became the A-3B.

Left: There was nothing high-tech about the cockpit of a Skywarrior. This is the front office of a KA-3B which was generally similar to earlier models. The eyepiece unit and circular radar screen were both part of the AN/ASB-7 bombing system. Although bombing capability had been deleted from this version the radar was used in directing the tanker and receiver aircraft to a rendezvous. A-3Bs, KA-3Bs and EKA-3Bs had a crew of three or four, depending on the mission. None was equipped with ejection seats, so crew escape was via an escape hatch linked to the cockpit by a tunnel/slide.

Far left: Whidbey Island was the shore base of 'Heavy Two' for over a decade. In January 1964, the squadron was near the top of the 'safety totem' for the seven heavy attack squadrons at the base, which is north of Seattle in Washington state.

Hotel went aboard 'Tico' on 4 October as part of Air Task Group One (ATG1) and remained aboard CVA-14 until February 1959. Meanwhile, Det Echo deployed aboard 'Bonnie Dick' on 1 November 1958 and did not return to Whidbey Island until June 1959. Shortly after Det Echo's return, Heavy Attack Wing Two, the parent unit since the commissioning of VAH-2 in November 1955, was decommissioned. Thereafter, VAH-2 and other Skywarriors at Whidbey were administered by COMFAIRWHIDBEY (Commander Fleet Air, Whidbey Island).

Significant events during that period included the loss of BuNo. 142640 on 18 September 1959 (the aircraft crashed near Napa, California), and the receipt by VAH-2 of its first Lot XI Skywarriors with the AN/ASB-7 bomb director and DECM (Defensive Electronic Countermeasures) in place of the tail turret.

On 28 December 1959, Commander Charles S. Porter relieved Commander Kenneth L. Gulledge (VAH-2 skipper since December 1958) as the fourth commanding officer. Commander Porter ran a competition in February 1960 to select a new insignia to replace the clumsy, ugly, ungraceful flying rhinoceros insignia initially adopted by VAH-2. From this contest, which was open to the public, came the 'Royal Rampants' name with which VAH-2 passed into history. Unfortunately, Commander Porter and his crewman, AQ2 Stewart E. Jackson, were killed on 26 March 1960 when their A3D-2 (BuNo. 142642) disintegrated while on a routine training flight 10 miles (6 km) south of Harrington, Washington. The XO, Commander William B. Barron, Jr who had just reported aboard from VAH-123, took over as skipper of the 'Royal Rampants'.

Fully operational

During the preceding 3.5 years, heavy attack training had concentrated on qualifying crews to deliver special (i.e., nuclear) weapons. This was finally achieved by VAH-2 during the summer of 1960 when the 'Royal Rampants' logged 2,530 hours while flying 11 A3D-2s between 1 April and 30 September, for a rather impressive average of nearly 30 flight hours per month for most pilots.

Having previously deployed crews and aircraft for detachments aboard '27-Charlie' carriers, the entire squadron prepared for a WestPac cruise with CVW-15 aboard the USS *Coral Sea* (CVA-43). As CVA-43 sailed from Alameda, California on 19 September 1960, its flight deck was loaded with 11 A3D-2s. However, that many 'Whales' were too many for even a 'Midway'-class carrier and, after reaching Hawaii aboard CVA-43, HATRON TWO flew nine of its Skywarriors to NAS Atsugi to await

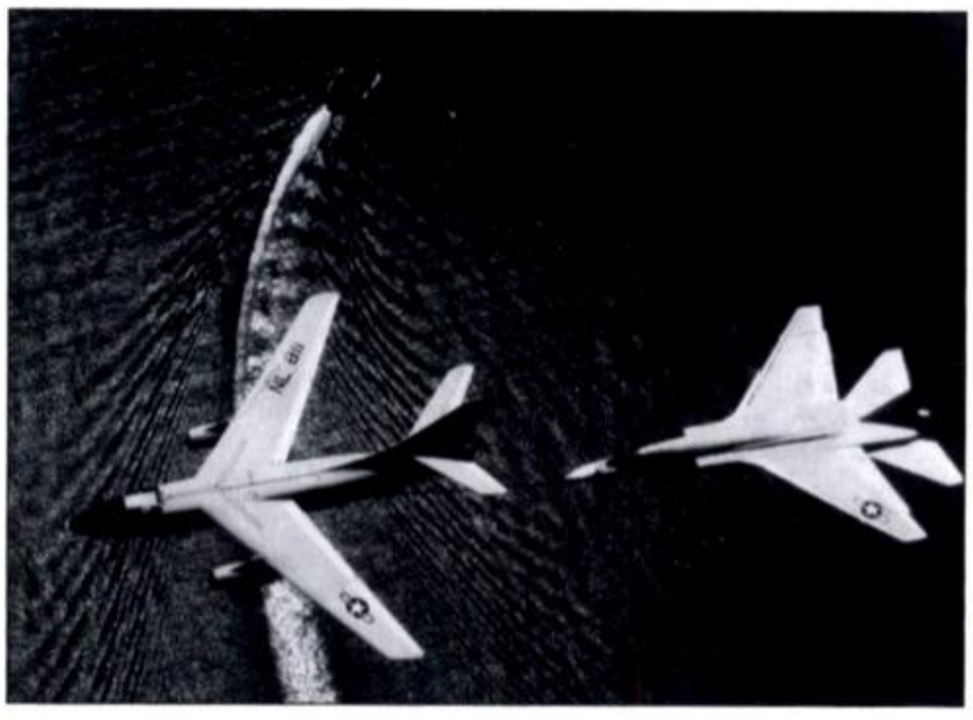
'Heavy Two' is seen in a rare squadron formation during pre-deployment training over southern California in late 1964. A whole squadron could be accommodated aboard a '27-C' carrier, although, for combat operations, the unit was split into detatchments.

Above right: While Det Mike was aboard* Ranger *for the first war cruise of the 'Rampants', the rest of the squadron were a few months behind, embarking once again on* Coral Sea *in December 1964. These 'Whales' of Air Wing Fifteen seen sunning themselves on deck in the spring of 1965 are late-build (Lot XI) aircraft with the Cambered Leading Edge (CLE) wing.

the carrier in Japan. During the remainder of the cruise, many A3D-2s were kept ashore. This precaution did not prevent the loss of BuNo. 142407, which was damaged beyond economical repair as the result of a non-flying accident aboard *Coral Sea*. When the carrier steamed home, VAH-2 made the 'transpac' flight to Whidbey led by its sixth skipper, Commander Leland. E. Kirkemo, who had relieved Commander Barron on 3 April 1961. For this return trip, the four A3D-2s of Det Alfa from Atsugi joined the six aircraft from Cubi Point at Midway. Two groups of five then made the trip to Barbers Point, arriving home on 20 and 21 May 1961 for a month of leave.

The next WestPac cruise saw the 'Royal Rampants' departing 6.5 months after returning stateside. Once again assigned to *Coral Sea*, VAH-2 continued to provide CVW-15 with its strategic nuclear punch. That cruise saw the loss of yet another VAH-2 crew as BuNo. 147668 – the last Skywarrior built – hit a mountain in central Luzon while coming in for a landing at Cubi Point on 13 January 1962. Three months later, in a traditional change of command ceremony at sea, Commander Kirkemo was relieved by Commander William D. Fries. Finally, six days before *Coral Sea* returned home on 17 July 1962, VAH-2 conducted flight operations in the Bering Sea, sending a warning to the Soviet Union (and also, perhaps, an almost equally needed political message to Congressional staffers who might have been too eager to reduce funding) that carrier aviation was a factor in nuclear deterrence.

The last peacetime cruise began on 1 April 1963, three days after Commander Rufus C. Small had become the new 'Head Royal Rampant', with nine Skywarriors flying



Well before the A-3 was deployed to Vietnamese waters, the capability to act as an airborne tanker had been added to the fleet. An A-3B could be converted to tanker configuration with about four hours work aboard ship. Here, as USS* Ranger *turns into the wind for recovery, a Skywarrior of Det Mike tops up a thirsty Vigilante of RVAH-5, during the 1964-65 cruise. The aircraft of Det Mike were marked with 800-series modexes, rather than the usual 600 series.

to NAS Alameda to be loaded aboard *Coral Sea*. During the 225-day deployment HATRON TWO not only operated from CVA-43 but also from ashore, in Australia (RAAF Townsville and RAAF Richmond), Guam (NAS Agana), Hawaii (NAS Barbers Point), Japan (NAS Atsugi), and the Philippines (NAS Cubi Point). As before, the emphasis during this cruise was placed on sharpening skills in the primary assigned mission, with simulated bombing missions being flown during Exercises Glassdoor in the Philippines-Taiwan area, Newboy in the Philippines, and Tireiron in the Japan-Okinawa area; ordnance delivery was practised over the Koon-ni Training Range in Korea and the Atsugi Radar Navigation Scoring Site in Japan. Also noteworthy was a four-aircraft, 3,000+-mile (4830+-km), eight-hour training sortie flown on 16 September 1963 with tanker support provided-by four KC-130Fs from VMGR-152. The cruise ended with the return of the 'Royal Rampants' to Whidbey in November 1963.

New roles

With the new year, just as the 'Royal Rampants' demonstrated their mastery of the bombing mission by winning for the second consecutive year the COMFAIR-WHIDBEY Top Bombing Squadron Trophy, mission changes were in the wind. In January 1964, VAH-2 participated in evaluation of mine delivery methods. More importantly, during the following months the squadron's A-3Bs underwent conversion to accommodate tanker kits, thus increasing HATRON TWO's multi-mission capability. In addition, as they were now slated to send Detachment Mike for operations with CVW-9 aboard the USS *Ranger* (CVA-61), the 'Royal Rampants' received three additional aircraft, four more flight crews, and support personnel (raising personnel strength from 29 officers and 230 enlisted to 39 officers and 307 enlisted).

On 17 March 1964, Commander Charles H. Lindberg had become the ninth VAH-2 skipper. Under his command, HATRON TWO was soon to go to war – not to deliver nuclear devices for which it had primarily trained since receiving its first Skywarrior eight years earlier but, mostly, to pass on gas.

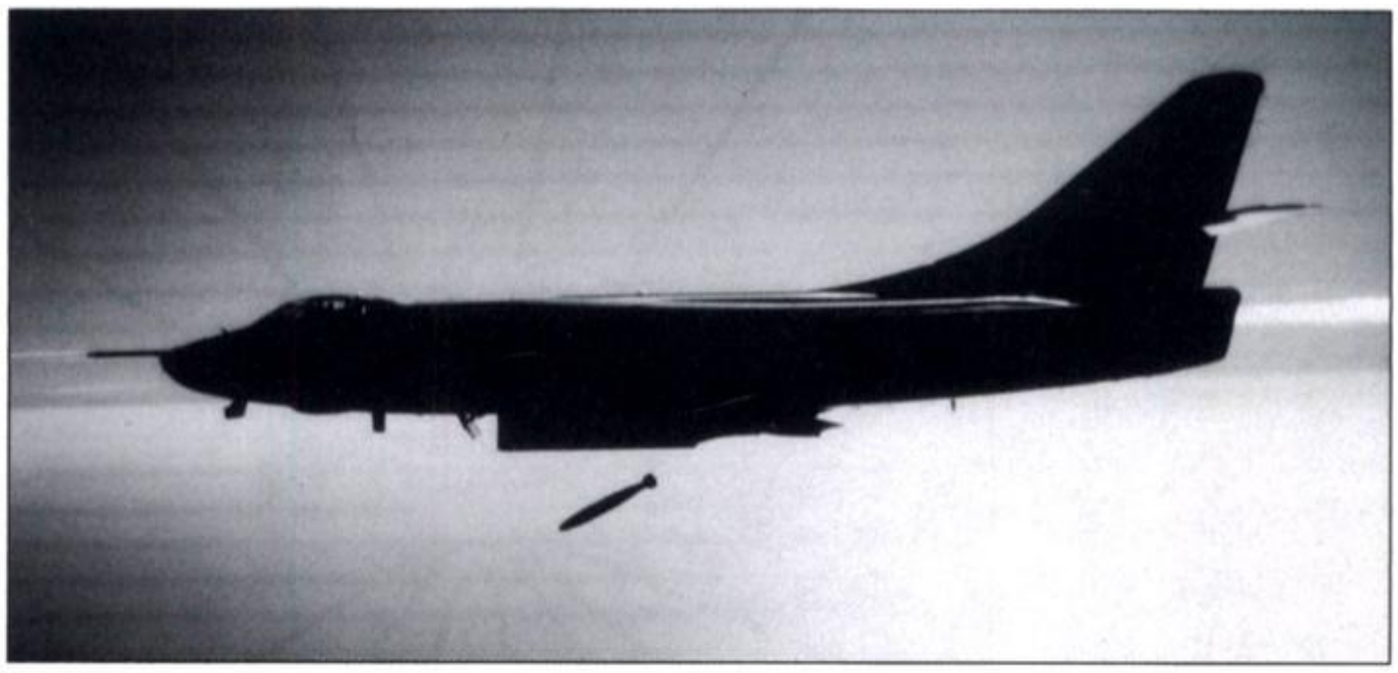
Joining the club

Formed in January 1964, and consisting of three tanker-configured A-3Bs, nine officers and 70 enlisted men, Detachment Mike went aboard CVA-61 to provide air refuelling to CVW-9 during a WestPac cruise. Departing San Diego on 5 August 1964, three days after North Vietnamese P-4 PT boats were perceived as a threat to the USS *Maddox* (DD-731) steaming on De Soto Sigint patrol in international waters off the coast of North Vietnam, Ranger proceeded to the Gulf of Tonkin and first went on the line on 18 September 1964. Now members of the 'Tonkin Gulf Yacht Club', the 'Royal Rampants' flew their first tanking sorties in support of combat operations

Wearing Aussie-style slouch hats – a favourite purchase of aircrew going ashore in Saigon – Crew Seven of VAH-2 pose with their 'Whale' on 29 March 1965 after the first bombing sortie. Pilot LCdr Lou Hettinger is at left, centre is bombardier/navigator Lt (jg) Bill Haushalter, and at right is the plane captain, AMH1 M. L. Sutherland.

on 17 December 1964. The three Det Mike aircraft were back at NAS Whidbey Island on 3 May 1965 after flying 2,100 hours during the nine-month cruise aboard *Ranger*.

In December 1964, the bulk of VAH-2 personnel and aircraft boarded *Coral Sea* for what became the longest carrier deployment to date. Leaving Alameda on 7 December 1964, CVA-43 and its Air Wing Fifteen did not return until 1 November 1965 after spending 167 days on the line. In the process, CVW-15 participated in over 160 major strikes, flew more than 10,800 combat sorties, delivered over 6,000 tons of ordnance, claimed the destruction of a North Vietnamese MiG-17 (shot down by Lieutenant Commander Dan Macintyre and Lieutenant (jg) Alan Johnson of VF-151 on 6 October 1965), and earned 1,091 medals and commendations. The price paid was heavy: eight flyers had been killed in action, one was missing in action, two were prisoners, and two sailors had been killed; 11 A-4C/Es, six F-8Ds, two RF-8As, and two A-1Hs were shot down by AAA or small arms fire; and an RF-8A and an A-3B were lost in non-combat accidents.

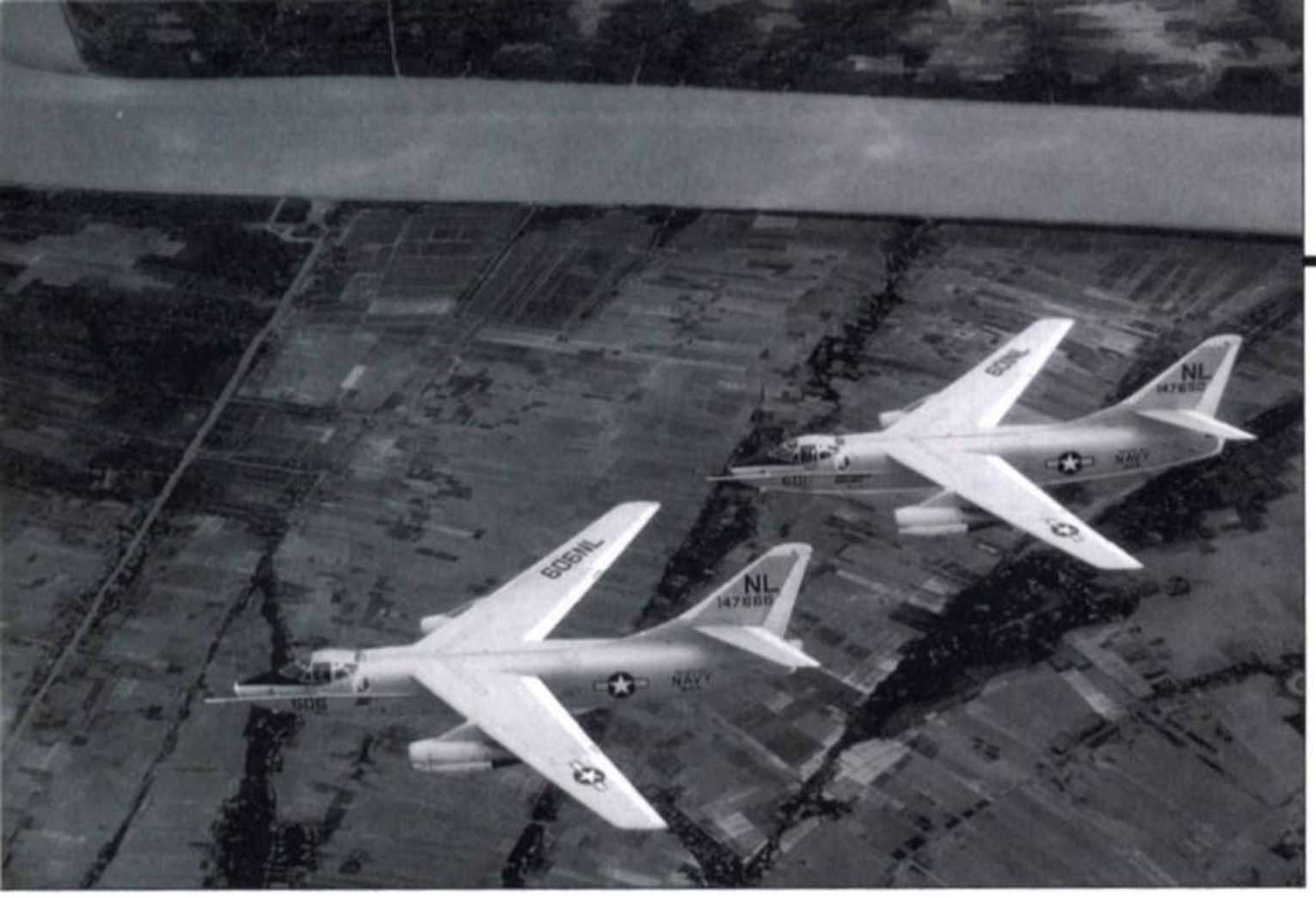


Several of the heavy attack squadrons managed to live up to their designation by dropping live ordnance in combat, albeit in a mission far from the original role of nuclear strike for which the Skywarrior was designed. Here an aircraft of VAH-2 is seen on a sunset bomb run over the North.

For HATRON TWO, this record cruise began with a notable event on the night of 13 December 1964 when three A-3Bs were catapulted from *Coral Sea* which was moored to the pier at Ford Island, Hawaii, the first such night launch for the Skywarrior. With *Coral Sea* going on the line on 1 February 1965, VAH-2 had less than a week of routine operations before combat tanking operations were initiated during the first Flaming Dart retaliatory strikes against barracks at Dong Hoi, north of the DMZ. Tanking support for Rolling Thunder operations was provided from 26 March 1965. However, it was not for 'passing gas' that the 'Royal Rampants' first made headlines: on 29 March, six of their A-3Bs became the first Skywarriors to drop conventional ordnance in combat. That same evening, Don Willis, then a B/N assigned to Crew Two of the 'Royal Rampants' with Commander John Sundberg and ABE1 Jim Thompson, recorded that mission as follows:

"The target, Ile Bach Long Vi or Ile Nightingale, was located in the middle of the northern part of the Gulf of

BuNo. 147655 is seen prior to its third bombing sortie in April 1965. The redshirts are loading World War II-era Mk 60-series box-finned bombs. The US expended the last of its World War II ordnance during the Vietnam conflict and began using pre-21st century weapons, including laser-guided bombs.



Above: A pair of HATRON TWO's A-3s is seen in tight formation over 'Charlie Country' in the delta area of the Republic of Vietnam. Such contempt for the enemy AA gunners was shown less frequently north of the DMZ.

Above right: Marked with 28 bombing tallies and two outline whale symbols, BuNo. 147650 is pictured after a nosewheel collapse on the deck of* Coral Sea *in 1965. The aircraft was repaired but was lost in a collision with a Vigilante on 6 October 1966.

Tonkin – 60 miles or so west of Hainan Island. Three actual drop areas, designated target 1 – radar site, target 4 – HQ (ours), and target 5 – Admin and barracks, were assigned to three two-plane groups, led, in order, by CO, XO, and Ops. The planning was all done last night rather hurriedly, since we got the final go only yesterday and half the crews flew most of the day.

"It was our third time to an aircraft when the final word was 'launch' – and that they did – almost cleared the flight deck but took time in launching all 'Whales' from waist 'cat'. With four Mk 83s (1,000 lb each) we grossed heavy – about 72.5 or so. Our call sign was FOLDER THREE and the bird was NL 608 (BuNo. 147660) – a tanker-configured 147 series. After rendezvous and outbound to first turn point, Commander de Lorenzi shifted lead to us – Lieutenant Commander Bob Vaughn, Lieutenant (jg) Dick Toft, and Dave Lippitt, AT1, were on our wing flying NL 602 (BuNo. 142649), with a load of eight 500-pounders. Radar and computer was sweet – real good gear – obtained fixes off Cap Mui Ron and an island off North Viet coast. Inbound to target experienced strong radar interference, eased up by changing mag freq, something usually not done The island, 1¼ miles long by ½ mile wide, finally broke out about 35 miles to go and by 30 was well in the ball park. No prominent return, unable to solve for winds – PDI erratic in close, but Commander Sundberg did some fancy jockeying – bomb check list was completed – signalled Thompson for bomb doors as range passed 40,000 ft and was preparing for manual backup when she released close to pre-comp R/R (BIP not on) – intervalometer was set for 4 at 150 – fired perfect, all 4. Our drop was at 1454. Commander Sundberg said, 'Well, you've just become the first heavy attack bombardier to make a drop on the enemy!' A quick glance at 602 and I saw a thumbs-up in their cockpit. They headed for Cubi. Shortly thereafter, the CO and Morgy were coming over the target.

Crew Two of VAH-2 during* Coral Sea *combat operations in March/April 1965 comprised Cdr J. P. Sundberg, pilot (left), Lt (jg) D. J. Willis, bombardier/navigator (second from left), and plane captain ABE1 J. L. Thompson (fourth from left).

"After Lieutenant Commander Richards and Terry tanked CAG, we topped them off and headed for 'Mustang'. Meanwhile, the A-4s were having their hands full. Heavy ground fire punctured two gas tank on the first pass; Commander Mongilardi, CO of VA-153, was hit and streaming fuel. Through help of 'Royal Lancers' they rendezvoused with our tanker – the VO was at 600 lb – Richards tanked him all the way to the ship and the deck was cleared for a straight in. We were recovered by this time and taking a hot refuel when Commander Mongilardi trapped.

"Tonight, Commander de Lorenzi answered the phone in the ready room with 'Bomber Squadron Two'..."

Following this momentous mission, VAH-2 spent 119 more days on the line, mostly providing tanking support for CVW-15 Rolling Thunder operations but also flying more bombing sorties. Conventional bombing, however, was not the best employment of the A-3B and, during the 1964-65 deployment, the 'Royal Rampants' made good use of the air refuelling capability of their Skywarriors by transferring 4,150,000 lb (1886363 kg) of fuel to other CVW-15 aircraft, and were credited with saving 17 jets.

With Commander de Lorenzi as the new skipper since 12 March 1965, HATRON TWO finally returned to Whidbey Island on 1 November 1965, minus one 'Whale'. On 24 February 1965, while *Coral Sea* was on its first line period in the Gulf of Tonkin, the crew of BuNo. 147664 had to bail out after an electrical failure shortly after launch resulted in a complete fuel transfer failure. Three of the crew were recovered but a chief was killed after becoming entangled in the shrouds of his parachute. Notwithstanding this loss, the 'Royal Rampants' had ample reason to be proud of their achievements, for they had flown 1,176 combat sorties, logged 4,873.6 flight hours, made 1,107 day and 449 night traps (with 35 crew members becoming 'centurions' after logging 100 or more traps), dropped 400,000 lb (181818 kg) of bombs on targets in North Vietnam and VC-controlled areas of South Vietnam, and completed 99 out of 100 assigned sorties. For their participation in combat operations in Vietnam, they had earned 163 Air Medals and 39 Navy Commendation Medals with Combat V.

Back for more

While most 'Royal Rampants' were still enjoying home leave after their record deployment, those assigned to Det Foxtrot departed Whidbey on 8 December 1965 for West-Pac deployment aboard *Ranger* with tanker-configured A-3Bs. After additional pre-combat training in Hawaii and the Philippines, Det Foxtrot got into business when CVA-61 began launching combat sorties on 15 January 1966. Spending 137 days on the line, the 'Royal Rampants' of Det Foxtrot mostly flew tanker ops – either as 'Strike Tankers' accompanying strike aircraft, 'Wet Wing Tankers' stationed between the strike zone and the carrier, or 'Over-Head Tankers' orbiting above the ship's position. In

the process, they transferred over 900,000 lb (409090 kg) of fuel and were credited with saving eight aircraft and their crews. In addition, the small HATRON TWO Det found time to deliver over 40,000 lb (18181 kg) of ordnance on Communist targets, to fly cargo support ops, and perform weather reconnaissance and pathfinding missions. Returning home on 25 August 1966, the men of Det Foxtrot totted 2,075 flight hours in their log books.

With VAH-2 once again split into small detachments, Commander John P. Sundberg became the 11th HATRON TWO skipper on 18 March 1966. By then, the next four-aircraft deployment was about to fall on the shoulders of Det Alfa, which settled aboard *Coral Sea* on 29 July 1966 and spent 109 days on the line in the Gulf of Tonkin before returning stateside – the carrier to Alameda and the 'Royal Rampants' to Whidbey – at the end of February 1967. The crews of Det Alfa flew 593 combat sorties, logged 1,683 flight hours, made 510 day arrested carrier landings and 148 night traps, transferred over 2,000,000 lb (907200 kg) of fuel, and were credited with saving four CVW-15 aircraft.

A bad month

For VAH-2, however, October 1966 proved unfortunate, as two A-3Bs and three 'Royal Rampants' were lost in four days. On 2 October, BuNo. 142633 went into the Gulf of Tonkin after the catapult bridle broke off during launch from the USS *Coral Sea*; luckily, all four crew members were recovered with only minor injuries. The Det Mike crew of BuNo. 147650 was not as favoured, for it was lost following a mid-air collision on 6 October with an RA-5C during refuelling while operating from the USS *Enterprise* (CVAN-65) off the coast of southern California. The RVAH-7 crew successfully ejected from its Vigilante and was subsequently recovered.

Five more tanker-configured A-3Bs and crews departed Whidbey on 8 November 1966 for Southeast Asia combat operations from the *Enterprise*. Spending 132 days on the line as part of CVW-9, Det Mike had particularly thirsty customers: its five 'Whales' transferred a total of 5,300,960 lb (2409527 kg) of fuel, saved four aircraft, and flew 1,947 hours before returning to Whidbey on 1 July 1967.

During 1967, VAH-2 underwent two changes of command, with Commander Donald K. Forbes relieving Commander Sundberg on 10 January and being in turn

The A-3 proved to be adaptable to a wide variety of conventional and 'special' ordnance. Here a crewman manoeuvres an M66A2 2,000-lb bomb toward BuNo. 147666 prior to its first bombing mission. The A-3 could carry more of these old bombs than it could Mk 84s with the same explosive capacity, and this was true of all the equivalent bombs in the Mk 60 and 80 series.

Left: With six bombing missions under its belt, BuNo. 147655 is manoeuvred at the fantail of Coral Sea. At right is an RA-3B from photo squadron VAP-61.

Far left: At some point during the 1964/65 Coral Sea cruise, the '604' modex was worn by another A-3B, 147656, sister ship to the above aircraft. It is seen here displaying the tanker package and two bomb symbols.

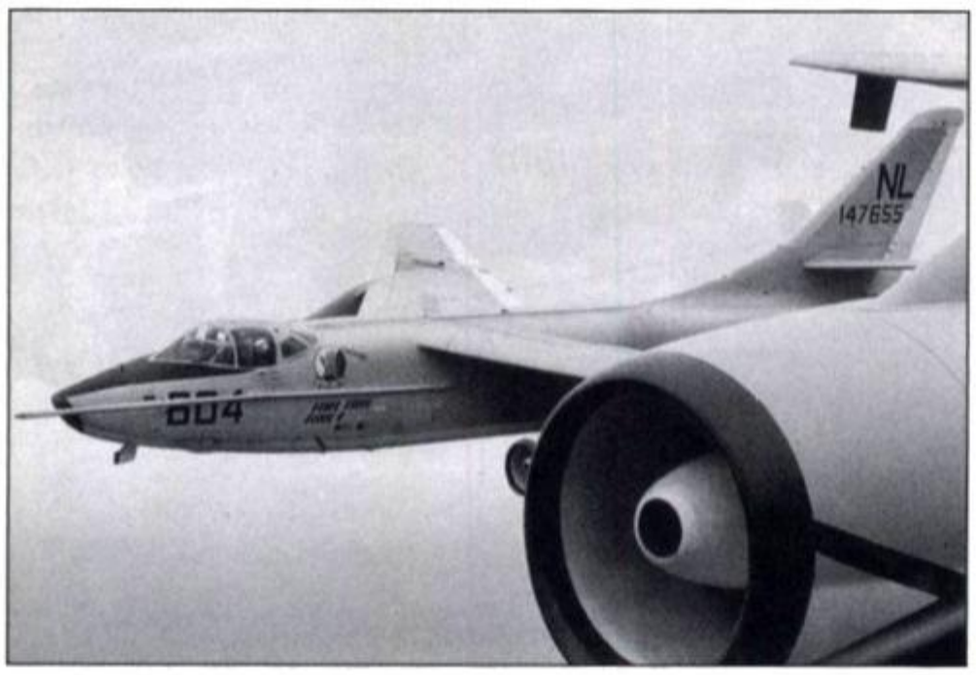
Left: With 16 missions recorded and wearing the 602 modex and the 'NE' code of CVW-2 (with which VAH-2 never served), 147656 is seen stateside.

Late production Skywarriors, such as this HATRON TWO aircraft seen going 'feet dry' over Cap Mui Ron in North Vietnam, were much modified compared to the 'Whales' initially assigned to the fleet. In addition to the CLE wing, the gun turret was removed – replaced by a DECM 'duckbutt' fairing – the refuelling package was added (restricting the bomb load), and the the ASB-1 bomb director system was changed to the new ASB-7 set.

relieved by Commander Jack D. Blackwood on 24 November. While the former was their skipper, the 'Royal Rampants' saw their mission changed on 1 July and their aircraft designated KA-3Bs. However, the name of the unit remained Heavy Attack Squadron Two even though it no longer trained for delivering bombs, conventional or nuclear.

During the second half of 1967, HATRON TWO operated 11 Skywarriors, with three KA-3Bs remaining in training stateside for deployment in 1968, four being assigned to Det 43 for deployment aboard *Coral Sea* beginning on 26 July, two with Det 61 aboard *Ranger* beginning on 4 November, and two with Det 65 scheduled to go aboard *Enterprise* just after the New Year.

Prior to their actual deployment, the detachments conducted the usual extensive carrier aviation training activities



After 16 bombing and numerous tanking missions, BuNo. 147655 returned to the US to become the first A-3 to undergo conversion to EKA-3B configuration. Later the aircraft became a KA-3B dedicated tanker.

The EKA-3B was designated a Tanker and Countermeasures Support (TACOS) aircraft and was fitted with a variety of VHF noise jammers, deception repeaters, signal analysers and SAM warning receivers, in addition to chaff dispensers. A standard fit for production A-3s was the bomb bay spoiler shown at lower left in this picture; it reduced buffeting when the doors were open.

and exercises with their respective air wing. These operations included refresher land-based training as well as shipboard training in the water operating areas adjacent to southern California. During the at-sea periods with their assigned carrier, the weapon exercises and Operational Readiness Exercises (OREs) were completed. After deployment, but prior to arrival in the Western Pacific, 11 detachments conducted their Operational Readiness Inspection (ORI) in Hawaiian waters. In 1967, all HATRON TWO detachments achieved their air wing highest grade.

New variant

Among the 1967-68 deployments by VAH-2 detachments, that by Det 43 was particularly significant as its four KA-3Bs were credited with saving no fewer than 21 CVW-15 aircraft during the first 90 days on the line. Still on the line aboard *Coral Sea* at the end of 1968, Det 43 returned to Whidbey on 6 April 1968. By then, two of its detachments, one aboard *Ranger* and one aboard *Enterprise*, were both on the line. During that same month, BuNo. 138921, one of the KA-3Bs assigned to Det 64 which began training for deployment aboard the USS *Constellation* (CVA-64) on 29 May, became the 11th and last Skywarrior lost while in service with HATRON TWO.

With Det 61 and Det 65 returning to Whidbey on 25 May and 18 July 1968, respectively, the Det 64 deployment became the final hurrah for the 'Royal Rampants'. Sea-based deterrence was now the sole responsibility of Polaris-armed SSBNs (Nuclear-Powered Fleet Ballistic Missile Submarines) and most of the remaining A-3Bs had been modified at NARF Alameda either as dedicated KA-3B tankers or dual-role EKA-3Bs, with these aircraft being assigned to newly activated Tactical Electronic Warfare Squadrons (known as VAQs or TACELRONs). The NARF Alameda programme covered a total of 90 aircraft, 85 initially modified as KA-3Bs and five as EKA-3Bs. Later modifications eventually resulted in 34 KA-3Bs being brought up to EKA-3B standard, while three of the initial batch of EKA-3Bs were redelivered to the Fleet as KA-3Bs. Still later, many EKA-3Bs had their electronic equipment removed, along with the related fairings on both sides of the fuselage fore and aft of the wings, to end up as KA-3B tankers with two Reserve squadrons.

VAQ-132 afterlife

While Det 64 was aboard *Constellation*, then on its fourth line period during the May 1968-January 1969 deployment to the Gulf of Tonkin, Heavy Attack Squadron Two was decommissioned at NAS Whidbey Island on 1 November 1968. On that date, Tactical Electronic Warfare Squadron One Three Two (VAQ-132) was commissioned at NAS Alameda with Commander Robert E. Fraser as commanding officer. With the redesignation, the squadron

Following the conversion to EKA-3B standard, the aircraft were assigned to newly-formed fleet electronic support (VAQ) squadrons. BuNo. 147655, seen at Alameda after conversion, still wears VAH-2 markings, although the mission tally has vanished beneath the forward ALQ-92 VHF noise jammer antenna. The four large ALQ-92 fairings were the distinguishing features of this version.

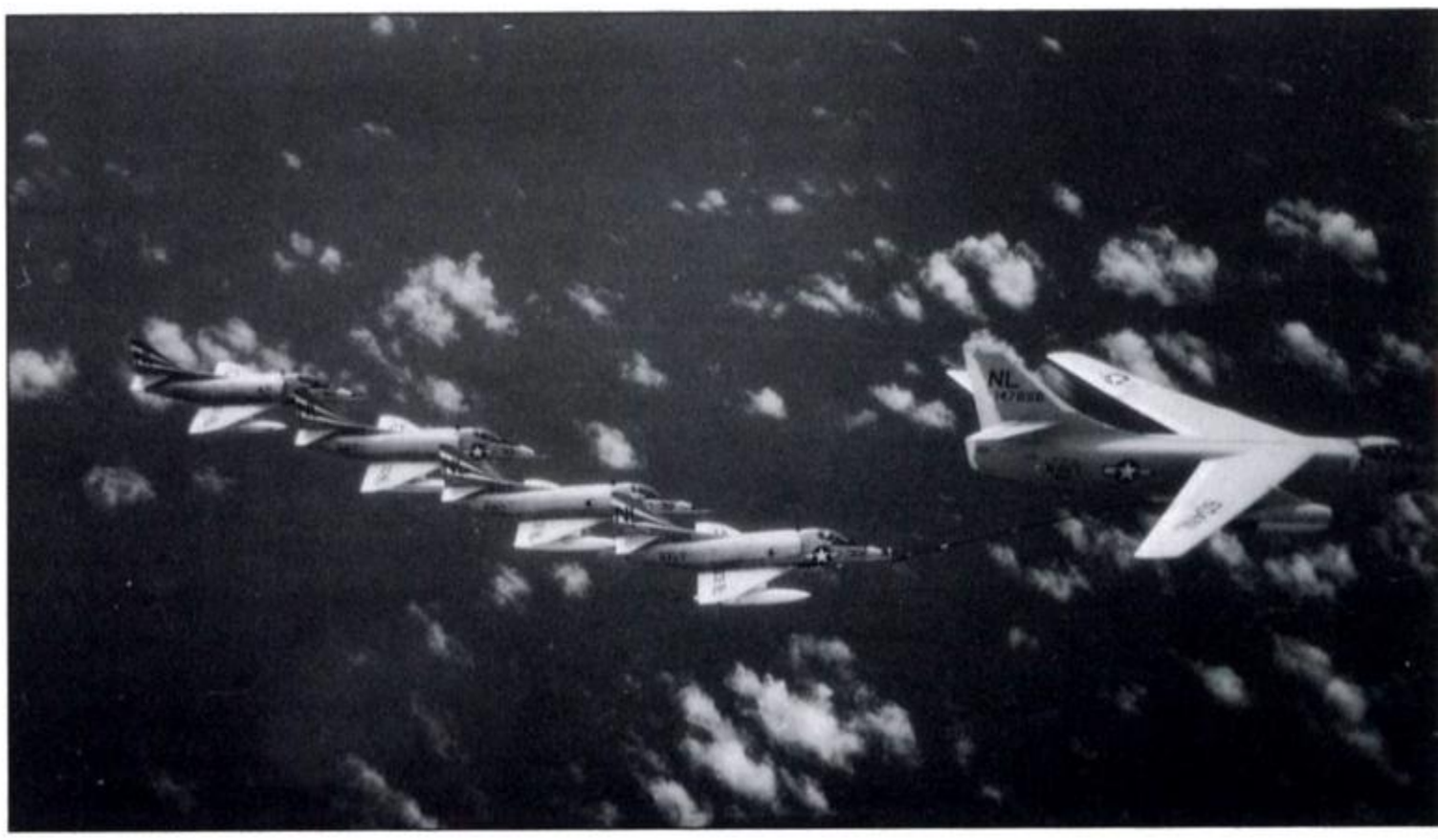
In order to have maximum transferable fuel for their next sortie, tanker-configured A-3Bs and KA-3Bs often landed at Da Nang for a top-up instead of recovering aboard the carrier. This KA-3B of VAH-2 Det 43 was photographed at the sprawling South Vietnamese base in 1968, where some effort was expended in locking closed the brake chute hatch.

VAH-2/VAQ-132 operational carrier deployments

Sqn/Det/Air Wing	Aircraft	Carrier	Tailcode/Modex	Deployment Dates
VAH-2 Det Bravo/CVG-15	A3D-2	USS *Bon Homme Richard* (CVA -1)	'ZA'/xx	10 Jul 1957 to 11 Dec 1957
VAH-2 Det Mike/CVG-9	A3D-2	USS *Ticonderoga* (CVA-14)	'ZA'/xx	16 Sep 1957 to 25 Apr 1958
VAH-2 Det Hotel/ATG-1	A3D-2	USS *Ticonderoga* (CVA-14)	'ZA'/xx	4 Oct 1958 to 17 Feb 1959
VAH-2 Det Echo/CVG-19	A3D-2	USS *Bon Homme Richard* (CVA-31)	'ZA'/x	1 Nov 1958 to 18 Jun 1959
VAH-2/CVG-15	A3D-2	USS *Coral Sea* (CVA-43)	'NL'/9xx	19 Sep 1960 to 27 May 1961
VAH-2/CVG-15	A3D-2	USS *Coral Sea* (CVA-43)	'NL'/6xx	12 Dec 1961 to 17 Jul 1962
VAH-2/CVG-15	A-3B	USS *Coral Sea* (CVA-43)	'NL'/6xx	3 Apr 1963 to 13 Nov 1963
VAH-2 Det Mike/CVW-9	A-3B	USS *Ranger* (CVA-61)	'NL'/81x	5 Aug 1964 to 6 May 1965
VAH-2/CVW-15	A-3B	USS *Coral Sea* (CVA-43)	'NL'/61x	7 Dec 1964 to 1 Nov 1965
VAH-2 Det Fox/CVW-14	A-3B	USS *Ranger* (CVA-61)	'ZA'/81x	10 Dec 1965 to 25 Aug 1966
VAH-2 Det Alpha/CVW-2	A-3B	USS *Coral Sea* (CVA-43)	'ZA'/6xx	29 Jul 1966 to 23 Feb 1967
VAH-2 Det Mike/CVW-9	A-3B	USS *Enterprise* (CVAN-65)	'ZA'/11x	19 Nov 1966 to 6 Jul 1967
VAH-2 Det 43/CVW-15	KA-3B	USS *Coral Sea* (CVA-43)	'NL'/6xx	26 Jul 1967 to 6 Apr 1968
VAH-2 Det 61/CVW-2	KA-3B	USS *Ranger* (CVA-61)	'ZA'/6xx	4 Nov 1967 to 25 May 1968
VAH-2 Det 65/CVW-9	KA-3B	USS *Enterprise* (CVAN-65)	'ZA'/x	3 Jan 1968 to 18 Jul 1968
VAH-2 64/CVW-14	KA-3B	USS *Constellation* (CVA-64)	'NK'/11x	29 May 1968 to 31 Oct 1968
(on 1 November 1968, VAH-2 Det 64 was redesignated VAQ-132 Det 64 while aboard *Constellation)*				
VAQ-132 Det 64/CVW-14	KA-3B	USS *Constellation* (CVA-64)	'NK'/11x	1 Nov 1968 to 31 Jan 1969
VAQ-132/CVW-9	KA/EKA-3B	USS *Enterprise* (CVAN-65)	'NG'/61x	6 Jan 1969 to 2 Jul 1969
VAQ-132/CVW-9	KA/EKA-3B	USS *America* (CVA-66)	'NG'/61x	10 Apr 1970 to 21 Dec 1970

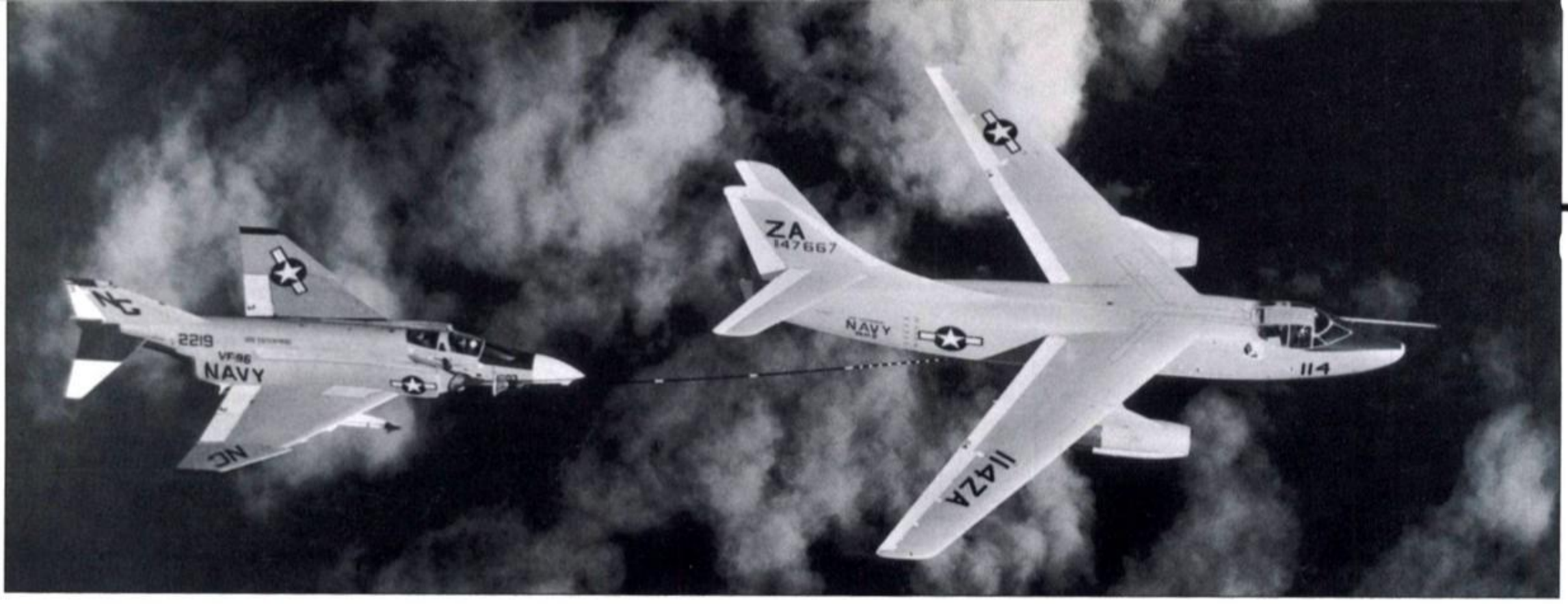
and personnel transferred from HATRON TWO – notably those with Det 64 aboard *Constellation* – were tasked with the dual mission of electronic countermeasures and inflight refuelling. The squadron's complement was set at five Skywarriors, three EKA-3Bs and two KA-3Bs.

The 'Scorpions' of VAQ-132 underwent their first carrier qualification period off the coast of California between 11 and 22 November 1968. ORE followed but was marred by the loss of BuNo. 138909 and its crew as the result of a launch accident aboard *Enterprise* on 3 December. Thirty-four days later, VAQ-132 sailed aboard CVAN-65 to undergo ORI off Hawaii at the start of a WestPac cruise. Tragically, flight operations had to be terminated on the second day of the ORI, 14 January, just before the second launch, when the ship experienced multiple ordnance explosions, immediately followed by a severe fire on the flight deck. Two of the squadron personnel were seriously injured and one died in the conflagration. One of the EKA-3B, BuNo. 138918, was consumed in the fire and three of its VAQ-132 aircraft were damaged by flying metal. Members of the 'Scorpions'



Even though HATRON TWO managed to drop bombs in anger and live up to its designation, the primary role of the squadron in Vietnam was aerial refuelling. Here A-4Cs of VA-153 'Blue Tail Flies' queue for gas during the 1964-65 cruise.

Left: During the 1964-65 deployment to the Gulf of Tonkin, VAH-2 transferred 4.15 million lb (1.88 million kg) of fuel and was credited with saving 17 jets which had incurred combat damage and otherwise would have been unable to return to the carrier or divert to a land base. The heart of the tanker package on A-3Bs such as BuNo. 147666 was the Flight Refuelling A-12B-7 hose reel housed under the fuselage.



***Above: In January 1968, VAH-2 Det 65 joined USS* Enterprise *for another cruise in Vietnamese waters. Some time prior to this deployment, this 'Whale' was photographed tanking an F-4B from VF-96 on* Enterprise.**

Right: During the 1964-65* Coral Sea *cruise, VAH-2 was only one of eight fixed-wing squadrons aboard. One of the others was VF-154 with F-8Ds, six of which were lost in combat. A lucky survivor of that cruise is seen here filling up from a VAH-2 tanker over the Tonkin Gulf.

Above: A close look at the external part of the tanker package is afforded by this deck edge view of a Skywarrior on the 'cat'. An A-3 remains the heaviest aircraft ever launched from a carrier.

The last carrier deployment for VAH-2 was on* Constellation, *beginning in May 1968 when Det 64 set sail for the Gulf of Tonkin. On 31 October the squadron was redesignated VAQ-132, with a mix of KA-3Bs and EKA-3Bs.

also lost clothing and personal effects, for their berthing area was completely destroyed.

After being temporarily shore-based while *Enterprise* was being repaired, the 'Scorpions' at last became members of the Tonkin Gulf Yacht Club and began combat operations on 31 March 1969. After spending 18 days on this first line period in the Gulf of Tonkin, CVAN-65 was hurriedly pulled out to steam toward the Korean peninsula and operations in the Sea of Japan and the Yellow Sea as part of a show of force following the shooting-down by North Korean MiGs of a Lockheed EC-121M from VQ-1. Once the crisis subsided, *Enterprise*, with VAQ-132 still aboard, returned to the Gulf of Tonkin. Only one more line period ensued and on 16 June 1969, the last day of combat operations, Commander James H. Eckart relieved Commander Fraser as CO of the 'Scorpions'. The five VAQ-132 aircraft then 'transpaced', arriving at Alameda on 26 June. The remainder of the squadron arrived back aboard the nuclear carrier on 2 July.

Return to the war

After post-deployment leave, training resumed in preparation for a return to combat operations in Southeast Asia. This time, however, VAQ-132 and the other PACFLT squadrons assigned to Air Wing Nine embarked aboard a LANTFLT carrier, the USS *America* (CVA-66). Accordingly, after carquals aboard *America* and ECM and refuelling training at NAAS Fallon (the 'desert carrier' in Nevada remained a Naval Auxiliary Air Station until January 1972), VAQ-132 deployed to NAS Leeward Point, Guantanamo Bay, Cuba on 10 January 1970.

While there, the squadron was credited with saving five A-7Es from VA-146 and VA-147 which, as the result of absence of approach radar, fouled runway, and bad weather, had to declare emergency fuel states. After training operations in the South Caribbean OPAREA aboard America, the 'Scorpions' returned to Alameda prior to going back aboard CVA-66 in April for ORE. With two KA-3Bs and most of VAQ-132 personnel aboard, the carrier then headed east around South Africa while the squadron's three EKA-3Bs flew west to Cubi Point. Reunited in the Philippines, the 'Scorpions' arrived on

Above: Compared to many contemporary naval aircraft, VAH-2's A-3s were not gaudily painted. Outside the Vietnam War period, however, a red lightning bolt was often applied to the fins of its Skywarriors.

Yankee Station on 26 May 1970. In the early morning hours of 5 July, during *America*'s second line period, BuNo. 142400 boltered with a deployed drag chute and settled into the Gulf of Tonkin. Fortunately, the three-man crew of this EKA-3B was recovered safely. That same day, Commander Richard A. Daleke became the third skipper of the 'Scorpions' during a change of command ceremony aboard *America*.

Three more line periods followed, bringing the number of days spent on station to 100, before it was time for CVA-66 and its CVW-9 to sail back home via Sydney and Rio de Janeiro at the tail end of its round-the-world cruise. The 'Scorpions' were back at Alameda on 19 December 1970 at the close of their last cruise with 'Whales'. Four weeks later, VAQ-132 moved from California to Washington – NAS Alameda to NAS Whidbey Island – to transition to the Grumman EA-6B.

With VAQ-132 converting to the Prowler, the only squadrons left operating KA-3Bs and EKA-3Bs were five active TACELRONs (VAQ-130, -131, -133, -134, and -135) and two newly commissioned Reserve squadrons (VAQ-208 and VAQ-308), all at NAS Alameda. With the active TACELRONs, KA-3Bs and EKA-3Bs soldiered on until June 1974 when VAQ-130 stood down at Alameda in preparation for its move to Whidbey and conversion to the EA-6B. The two Reserve squadrons kept their KA-3Bs until disestablished on 30 September 1988 (the 'Griffins' of VAK-308, ex-VAQ-308) and 30 September 1989 (the 'Jockeys' of VAK-208, ex-VAQ-208).

Tanker extraordinaire

Although the EA-6B proved to be a better EW platform than the elderly and jury-rigged EKA-3B, the Navy has never had a carrier aircraft matching the tanking capability of the 1967-vintage KA-3B. The amount of fuel that can be transferred depends, obviously, on mission profile, thus making direct comparisons difficult. However, using the HI-LO-HI mission profile included in the Standard Aircraft Characteristics charts for these two aircraft, one can learn that a KA-3B could transfer up to 29,150 lb (13250 kg) (about 4,485 US gal/16980 litres, or more than 2.2 times the internal tankage of the F-4J) of JP-5 when operating 400 nm (460 miles; 740 km) from the boat, while the KA-6D could only transfer 10,200 lb (4636 kg) (1,570 Imp gal/5945 litres, or less than the internal tankage of the F-4J). At that distance, the EKA-3B could still transfer twice as much fuel as the KA-6D, while also being able to provide electronic countermeasures and chaff jamming for the strike package. Today, the tanker-configured S-3B is even less capable than the KA-6D, leaving a glaring gap in naval capabilities as increased reliance on the short-legged F/A-18C/D makes for a greater need for air refuelling. (During Desert Storm, had it not been for the availability of USAF KC-135 support, aircraft from carriers in the Red Sea – including the supposedly long-legged A-6Es – would have been of little use.)

Unfortunately, in time of fiscal restrictions aircraft considered less 'sexy', such as tankers, are the first items to be lined out of budget requests. **René J. Francillon**

One of VAQ-132's EKA-3Bs is seen crossing the ramp of USS Enterprise in late 1968. During work-ups for the next Vietnam deployment, a disastrous fire destroyed 15 air wing aircraft and killed 27 men, including one member of the squadron. The surviving aircraft returned to Alameda until repairs to the ship had been completed, in January 1969.

Below left: In November 1968 the 'Royal Rampants' received new aircraft, a new designation and a new name. Pictured at Alameda a year later is an EKA-3B of VAQ-132 'Scorpions'.

Below: A 'Whale' drops in for a 'pinky' (sunset) landing. Although the A-3 is now gone from US Navy service, the 'Scorpions' maintain the fine traditions of VAH-2 and VAQ-132, flying EA-6B Prowlers from Whidbey Island.

A P-70 of the 6th Night Fighter Squadron runs up its engines on 12-Mile Strip, New Guinea prior to a test flight. The 6th (with two detachments) was the first and most successful of the units to fly the P-70 in combat.

P-70 in the Pacific

In 1940, the USAAF woke up to the need for squadrons specialising in night defence. Until a purpose-built night-fighter could be produced, the only solution was to adapt an existing bomber design. The resulting Douglas P-70 was never totally suitable for the role but, flown by a handful of units in the Pacific, it pioneered the tactics that would be used by the famous Black Widow in the final part of the war.

As war threatened Europe in the late 1930s, there were very few new aircraft designs on the drawing boards in the United States. The P-40, P-38 and B-17 seemed to be more than enough to handle any problems that might crop up over the next decade.

When Germany attacked England, the status quo approach gradually began to disappear. Aircraft production accelerated overnight, with large numbers of aircraft such as the A-20 and Ventura going to the RAF on a lend-lease agreement. When the Luftwaffe began achieving significant success at night, many eyes were opened, especially within the management ranks of the US Army Air Corps.

Having the capacity to carry out effective aerial attacks, at night, was a move toward the future. The RAF had responded to the Luftwaffe with an extremely effective night-fighter programme, and the skies at night over England and France were crowded with both fighters and bombers. The necessary skills and tactics to counter any enemy nocturnal activities were perfected by the RAF. The Americans used this knowledge to build their own force.

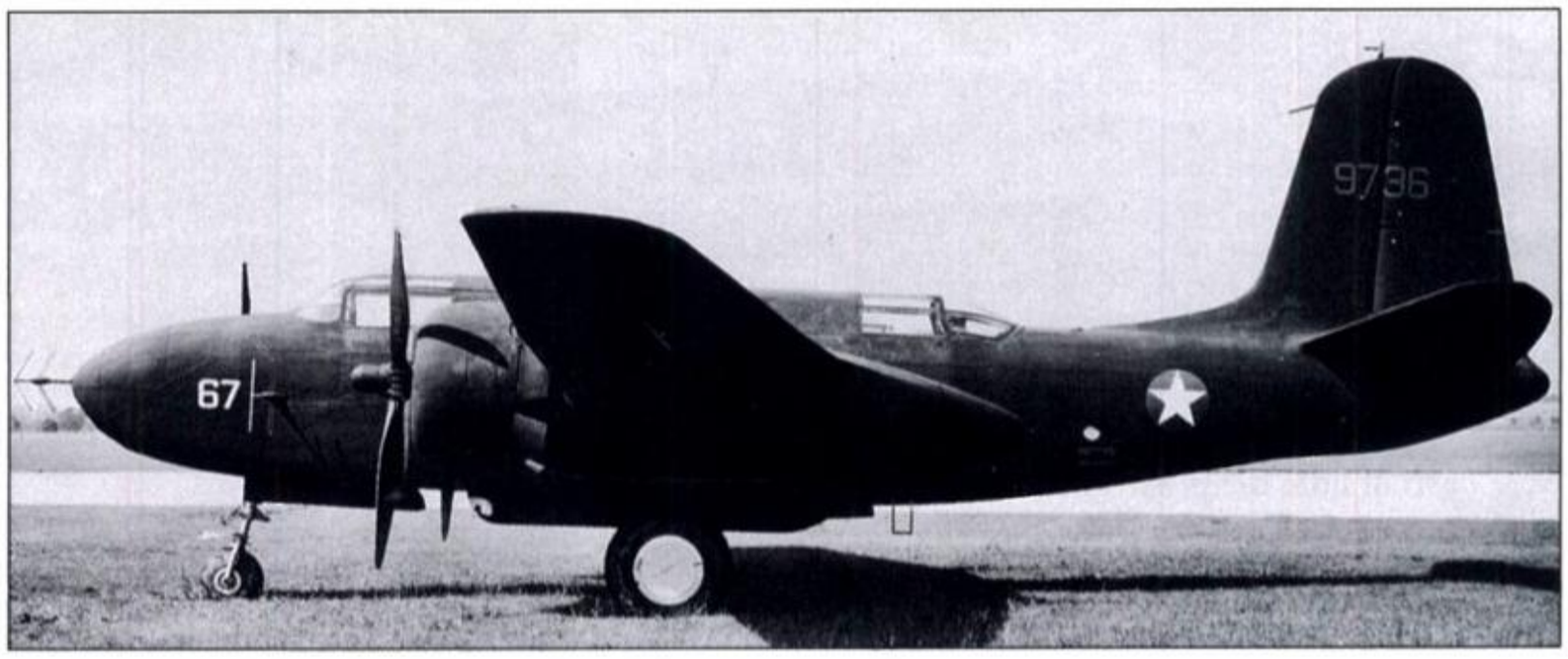
However, there was one ingredient missing – a night-flying aircraft. Northrop had already been hard at work to develop the ultimate fighter for this role, but the final product was still two years away. There had to be an immediate solution, a stopgap measure. After numerous discussions and meetings, it was decided that the A-20 light attack bomber should be converted and used until the P-61 was ready.

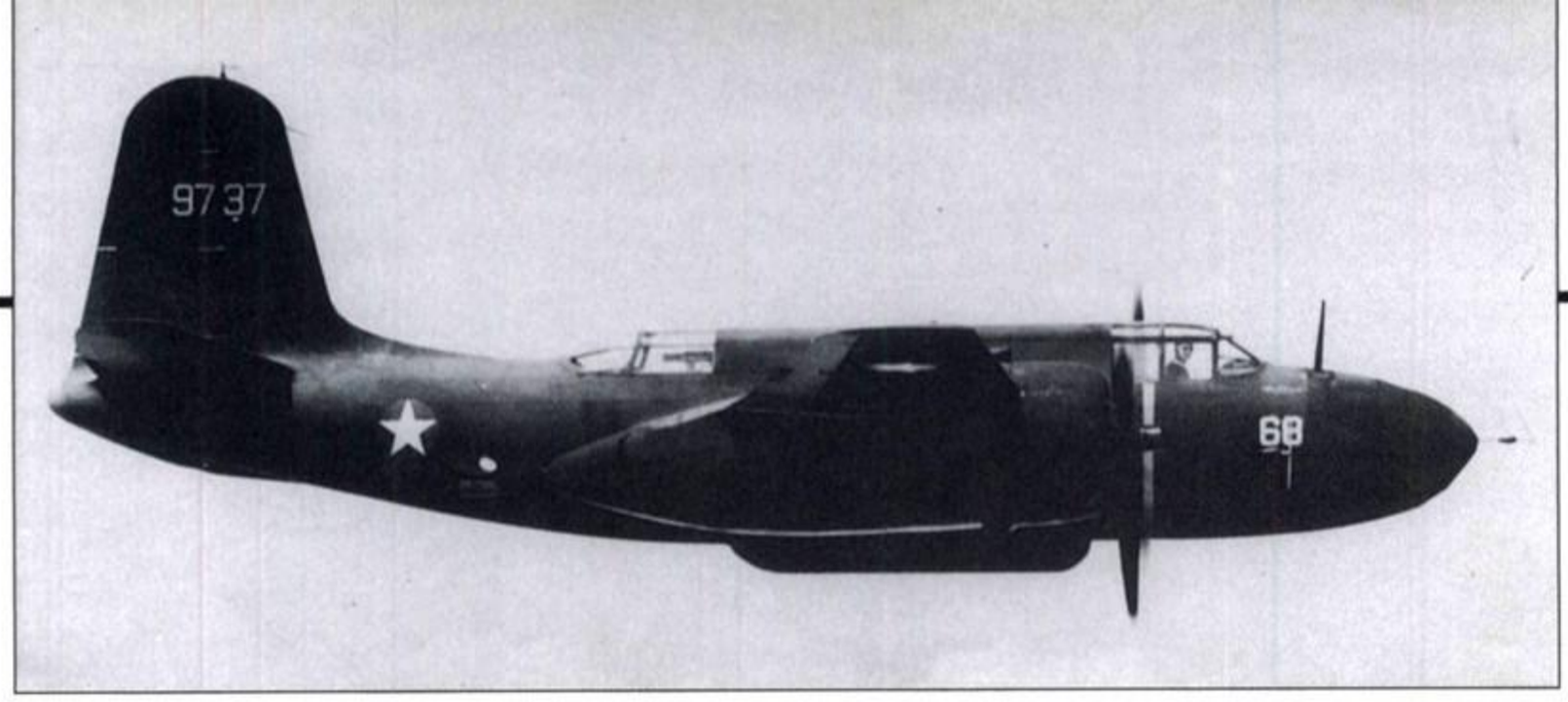
This decision only called attention to another problem. The A-20 was one of the most sought-after combat aircraft then in production in the US. The British used the A-20 in large numbers (known as the Boston), and wanted as many as they could get their hands on. Simply put, there just were not enough to go around.

The Pentagon was not moved by the demand, and the decision to use the bomber in a night-fighter role remained firm. The first A-20 to be converted was S/N 39-735, which, as the XP-70, had its forward nose modified to house the Airborne Intercept radar (AI). The model used was the British Mk IV. When copied in the US, it was designated the SCR-540.

Flight testing of the 'XP' was satisfactory enough for production to begin on this stopgap aircraft. On 15 October 1941, authorisation was given to start converting the remaining 59 A-20s into the P-70 configuration.

This is the first production P-70, 39-736, photographed at Wright Field in 1943 when it was in the Test and Training Squadron. Like the 58 subsequent P-70s, it was little different to the sole XP-70, 39-735.

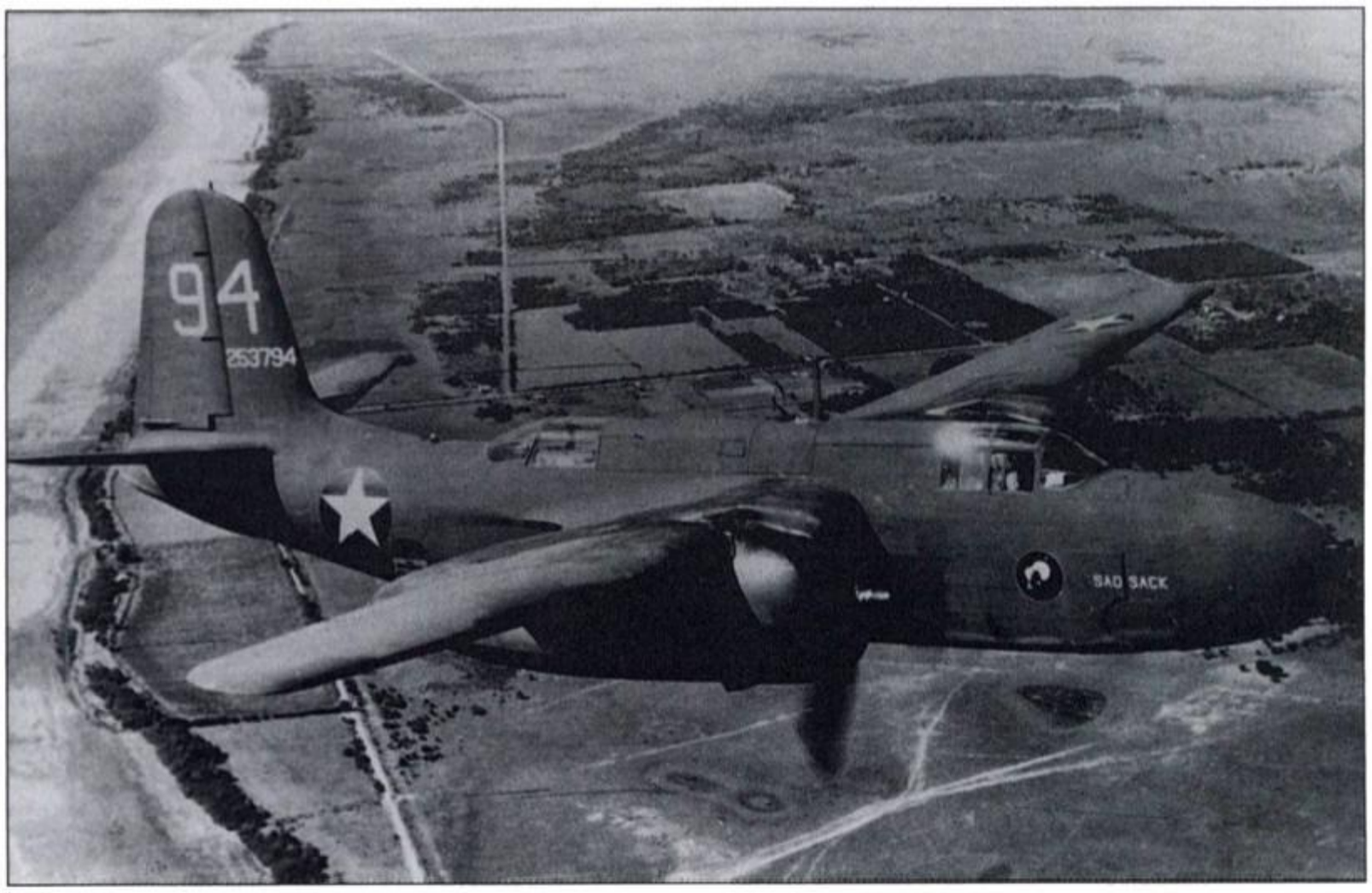




P-70 in the Pacific

Twenty-four of the 59 P-70s converted by Douglas went straight to Florida to train night-fighter crews. The second production P-70 is seen in 1942 while on the strength of the 81st FS (Sp) of the Fighter Command School based at Orlando.

Below: Many of the later P-70As (converted A-20s) found their way into the training units. Sad Sack *was a P-70A-1 in use with the 348th NFS at Orlando AAB in 1943.*



Conversion changes included a 24-volt electrical system. The bomb bay would not be used in this new role, so a 250-Imp gal (1135-litre) fuel tank was installed there. All standard armament on the A-20 was removed, and in its place a 'tub' was installed on the underside of the belly. It housed the P-70's sting of four 20-mm cannon. Each gun was allowed 60 rounds of ammunition, which would limit the extent of any multiple engagements during a night's mission. When the XP-70 was being tested, it was determined that when the cannon were fired the aircraft lost about 20 kt (23 mph; 37 km/h) of airspeed.

In the meantime, other aircraft types were considered, especially right after the Japanese attack on Pearl Harbor. Colonel James Alford, one of the members of the early night-fighter programme, stated, "Immediately after 7 December, the Japanese began making reconnaissance missions, almost nightly, to determine the extent of damage done to the Navy at Pearl and also to try to pinpoint the location of the US aircraft-carriers. These blatant intrusions had to be countered.

Night-fighter programme

"Phase I of the night-fighter programme began as a composite squadron of P-26s, P-36s and P-40Bs. These aircraft were to be flown by some of the older and more experienced pilots. The missions were extremely tough and our first attempt to fly effectively in this new environment proved to be both inefficient and undesirable! The reasons were numerous!"

Phase II was initiated when 7th Fighter Command realised that it had to select one of the most highly skilled day fighter squadrons (Pacific Theatre) to be the designated night-fighter squadron. It would develop and execute training and tactics, much of which had been passed over from the British. Use of the airborne searchlight emerged as a viable tactic during this phase. The squadron chosen for this tough assignment was the obvious one – the 6th Pursuit Squadron based in Hawaii.

The 6th's lineage dated to March 1917. On 6 May 1939, it had been designated the 6th Pursuit (Interceptor) Squadron. On 15 May 1942, it became known as the 6th Fighter Squadron and, after the arrival of the P-70s, the 6th Night Fighter Squadron. By the end of the war, the 6th had 16 confirmed enemy kills, ranking it second among night-fighter squadrons in the Pacific. (The 418th NFS was credited with 18 kills.)

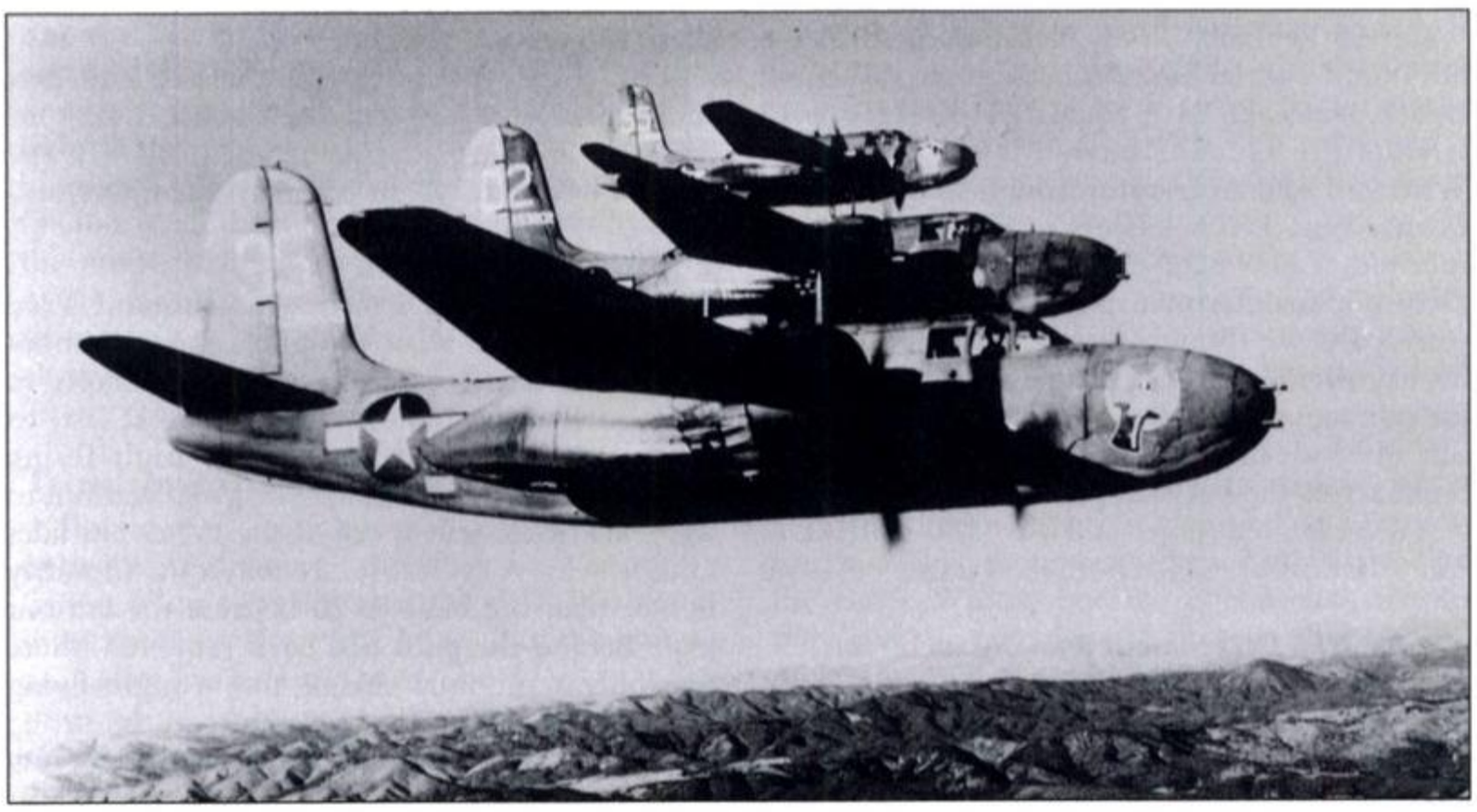
By mid-1942, the A-20 Havoc was probably the most desired aircraft being produced in the United States. All theatres were utilising its capabilities to the maximum. However, when all the dust settled, 12th Air Force had top priority for any new available A-20G models. The campaign in North Africa had taken on a 'most favoured status'.

The battle to recapture Guadalcanal in August 1942 was a long and bloody campaign. It highlighted just how thin the American forces were in the Pacific, but they fought with what they had and held their ground. General George Kenney, in a desperate plea, asked for more A-20Gs. Without hesitation, he was turned down, as the priorities had not changed.

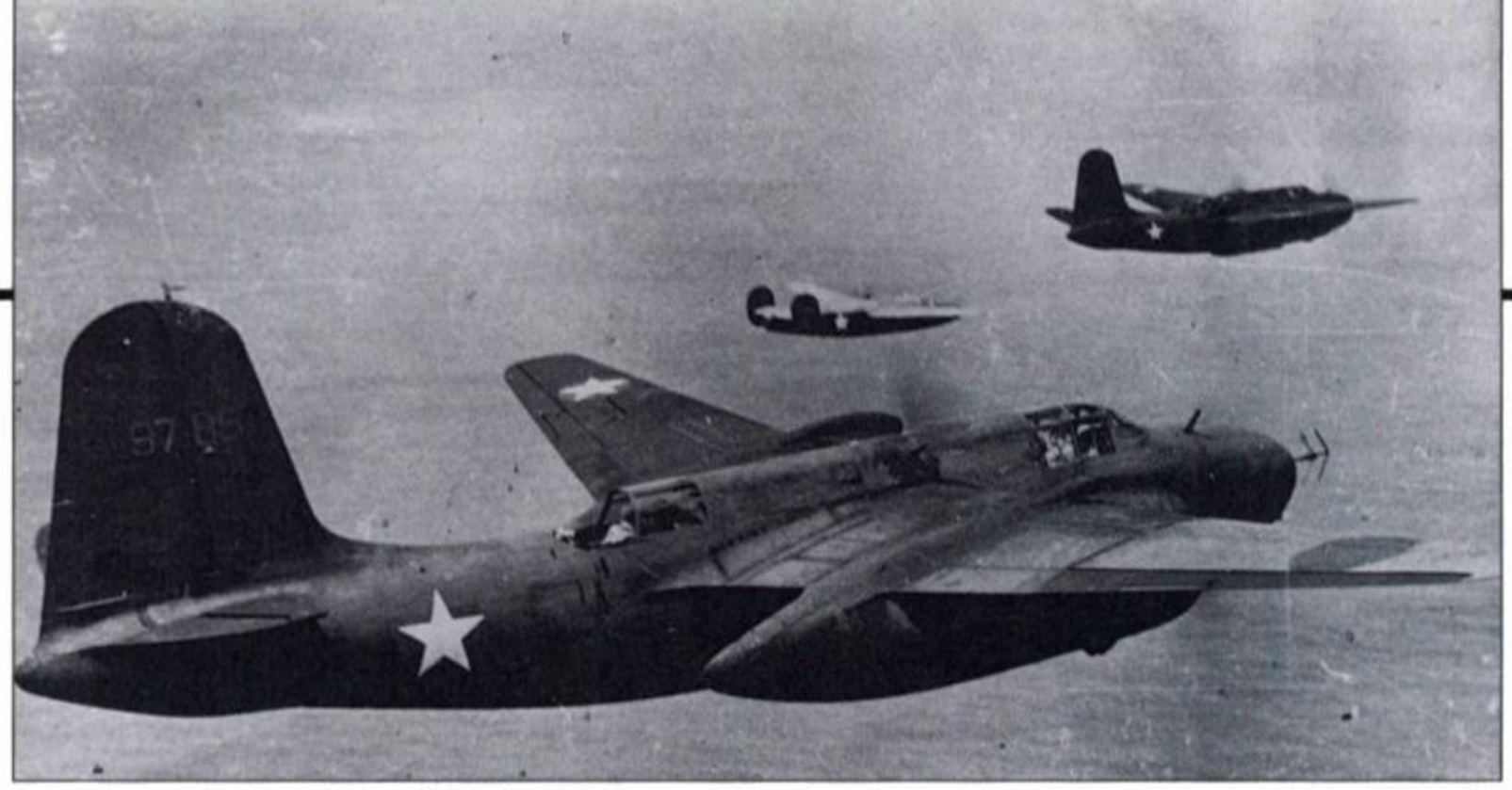
Nocturnal raiders

The Japanese raiders, hell-bent to resupply 'the 'canal' and get the American forces out, flew up and down the 'Slot' at night, with little or no opposition. Japanese air bases in the Russell Islands were only 30 minutes away and the big bases at Munda were only one hour's flying time away. This close proximity to Guadalcanal made it possible for the same enemy aircrews to fly more than one sortie each night. The Allied day fighter squadrons were unable to put up anything after dark. Their aircraft did not have the necessary equipment and the pilots were not trained in night flying. The results would have been disaster and the ability of friendly air power to resist during daylight hours would have been significantly affected. The time had come for a night-fighter unit, with no excuses accepted.

Finally, in September 1942, 25 P-70s arrived



In January 1944 the night-fighter training units moved to the San Joaquin Valley of California. These aircraft, based at Salinas Army Air Field, were P-70As with four 0.50-in machine-guns in the nose rather than the 20-mm cannon pack of the original P-70s.



For the long journey from the continental US to the Solomons, the P-70s of the 6th NFS Detachment A were accompanied by a pair of LB-30s containing the ground personnel and support equipment. When the weather closed in, the fighters had to tuck in as close as possible to the LB-30, for it also provided the navigation for the whole flight.

in Hawaii to equip the 6th. The battle for Guadalcanal was beginning its second month and time was critical. After a brief period of training, the squadron sent a detachment of aircraft and personnel to the Solomon Islands (Detachment B).

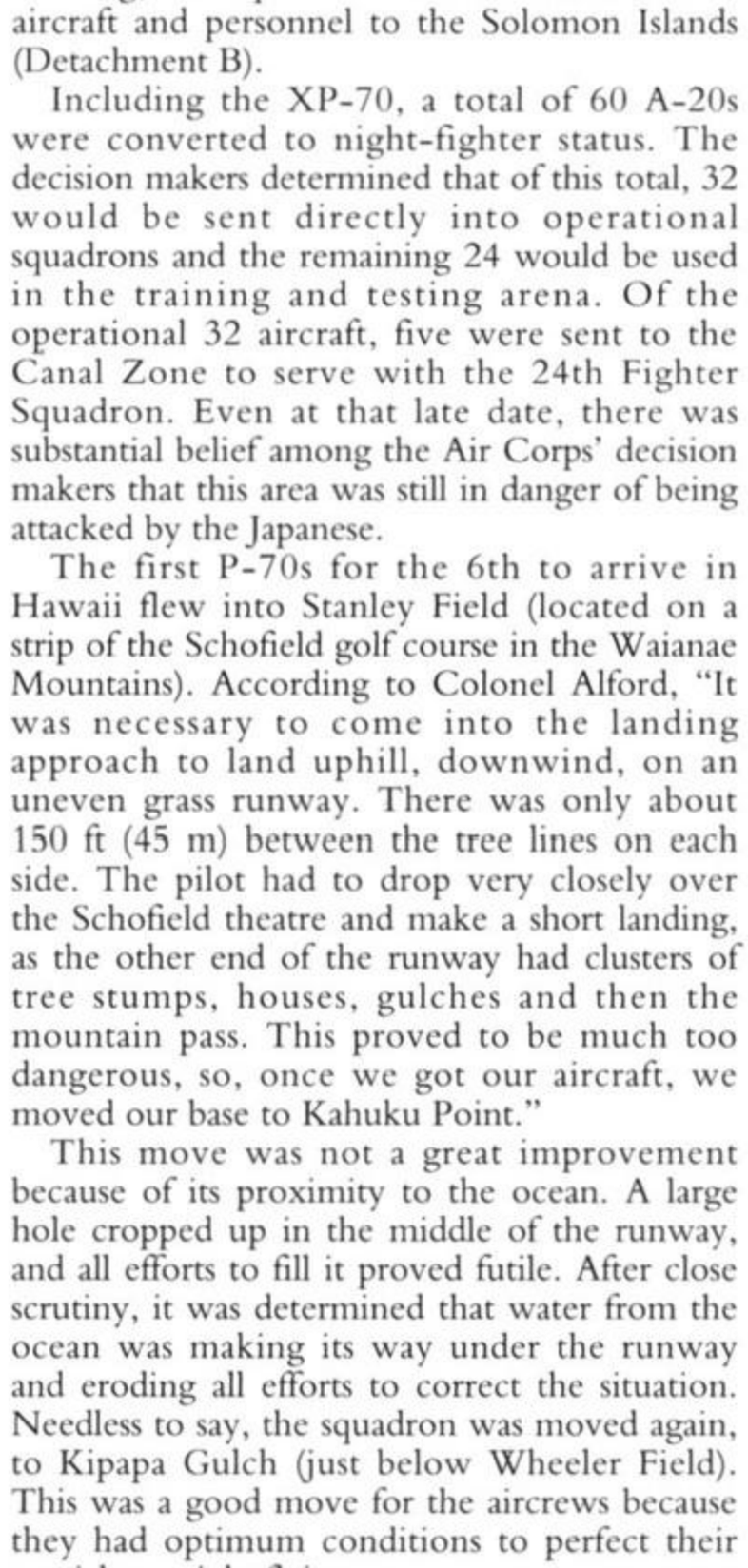
Including the XP-70, a total of 60 A-20s were converted to night-fighter status. The decision makers determined that of this total, 32 would be sent directly into operational squadrons and the remaining 24 would be used in the training and testing arena. Of the operational 32 aircraft, five were sent to the Canal Zone to serve with the 24th Fighter Squadron. Even at that late date, there was substantial belief among the Air Corps' decision makers that this area was still in danger of being attacked by the Japanese.

The first P-70s for the 6th to arrive in Hawaii flew into Stanley Field (located on a strip of the Schofield golf course in the Waianae Mountains). According to Colonel Alford, "It was necessary to come into the landing approach to land uphill, downwind, on an uneven grass runway. There was only about 150 ft (45 m) between the tree lines on each side. The pilot had to drop very closely over the Schofield theatre and make a short landing, as the other end of the runway had clusters of tree stumps, houses, gulches and then the mountain pass. This proved to be much too dangerous, so, once we got our aircraft, we moved our base to Kahuku Point."

This move was not a great improvement because of its proximity to the ocean. A large hole cropped up in the middle of the runway, and all efforts to fill it proved futile. After close scrutiny, it was determined that water from the ocean was making its way under the runway and eroding all efforts to correct the situation. Needless to say, the squadron was moved again, to Kipapa Gulch (just below Wheeler Field). This was a good move for the aircrews because they had optimum conditions to perfect their specialty – night flying.

Lieutenant Emmett Kearney, a pilot in the 6th during the early days, recalled when the first P-70s began to arrive: "In September (1942), I believe there were three groups of pursuit planes (Army Air Corps) operating on Oahu at Wheeler Field, Kipapa Gulch, Schofield Barracks Golf Course, Bellows Field, and Kualoa Strip. Most of the squadrons consisted of P-40s and I think one squadron had P-39 Airacobras. Usually, there was only one squadron at each airfield.

"The P-40s were our only night-fighters at the time. When fighter control at Ft Shafter scrambled a squadron, before dawn, we would run to our planes (started up by our crew chiefs at the sound of the scramble bell), leap up into the cockpit, buckle on our parachute and pour on full throttle, thundering off into the black night in tight two-ship formations. It was exciting and very scary since all we could see was our element leader's running lights and the blue flame coming from his exhaust stacks. We were able to get 12 P-40s into the air in less than four minutes, after the scramble order was received."



The 6th NFS Detachment B finally set off for Guadalcanal on 18 February 1943. With no ground-based navigation aids, the P-70s were dependent on the LB-30s for guidance. Sadly, one aircraft became lost in a squall and neither it nor its crew were ever seen again.

Boosted armament

Once the full complement of P-70 aircraft was received by the 6th, it was made known that the night-fighter was going to receive additional firepower. Lieutenant Ehlert stated,"Our fighters were going to be further equipped with a pair of 0.30-in calibre machine-guns to fire out of the opened rear cockpit and a single 0.50-in that would fire out of the lower access hatch for the rear cockpit. The 0.30s had a fair effective azimuth coverage as they could be swung from side to side on a single track. The 0.50 firing through the access door was severely limited in its area of effective firing, and would only be effective against another aircraft if it was directly behind and slightly below. However, this gun proved to be very valuable on a low-level strafing run."

On 18 February 1943, Detachment B of the 6th Night Fighter Squadron, with six P-70s and two LB-30s (B-24s), departed the Hawaiian Islands for Guadalcanal. Major Sydney F. Wharton, squadron commander, led the flight. Lieutenant Dick Ehlert, of the 6th NFS, recalled, "The plan called for the LB-30s to carry our maintenance personnel and whatever spare parts we thought would be required for a 30-day period. Besides providing transportation for our support people, the transports were also our only means of navigation for the lengthy flight across the Pacific.

"We planned stops at Hilo (180 miles/290 km distance), Christmas Island (1,400 miles/2253 km), Canton Island (900 miles/1448 km), Wallis Island (500 miles/805 km), Fiji Islands (1,000 miles/1610 km), and on to Espirito Santo in the New Hebrides. Here we would remove the auxiliary bomb bay tanks and reinstall the AI equipment, prior to our moving over to our destination – Guadalcanal. Our final leg into the combat zone would take about three and a half hours of flying time. We departed Espirito Santo on 28 February for the flight to Henderson Field."

Crew chief Sgt Raoul Morales poses by his P-70,* Black Widow, *at the 6th NFS base on Hawaii. The aircraft's name was a coincidence, as the P-61 project was still secret.

The flight from Hawaii marked the first long-distance, overwater flight in an A-20-type aircraft, and, up to this time, probably the longest overwater flight made by any fighter.

P-70 performance

One of the 6th's pilots, Lieutenant Fred Secord, sums up what the pilots thought about the P-70 after they had had the opportunity to fly it in Hawaii and were prepared, at last, to take it into combat against the high-flying Japanese 'Betty' bombers: "The P-70 was fun to fly, it had excellent speed at the lower altitudes and it was very stable. It was considerably lighter than the basic A-20 because the armour plate behind the pilot had been removed (there was only a minimal chance that a night-flying P-70 would be shot at from the rear). Its strong point was speed and manoeuvrability below 10,000 ft (304 m). There were a few times that

Above: Lt Fred Secord and Flight Officer Carl Hale of the 6th NFS Detachment A made a spectacular arrival at Townsville with a jammed nose gear, resulting in a belly landing. Here, mechanics refit the gun tub at Archer Field, Brisbane.

Left: Their aircraft repaired, Secord (right) and Hale prepare for the last stage of their long journey to battle. The ferry flight from the US to New Guinea involved the longest overwater flights by fighters up to that time.

Below: Night-fighters finally reached the Pacific combat theatre in February 1943 with the arrival of the 6th NFS Detachment B at Henderson Field. Down to five aircraft, the P-70s made a pass in 'parade' formation, as seen here, and then did it again at about 30 ft (10 m).

I got in dogfights with P-47s, down in Brisbane, and I found I could easily out-turn them at low altitudes. But, with no supercharger, the '70 had to struggle to get above 20,000 ft (6098 m)."

When what the pilots knew about their night-fighter was combined with what Intelligence was telling them about Japanese bomber activities, it became obvious that it was not the aircraft for the job they were being asked to do. Lieutenant Ehlert added, "Cutting down on the weight of the aircraft just didn't help it get up to the altitude of the enemy bombers. When I would try to reach 29,000 ft (8840 m), all the aircraft would do was hang on the props. Making a 5° turn would cause a loss of 300 ft (91 m) of altitude. It was this inability to effectively reach 25,000 ft (7620 m) and above that doomed the P-70 as an interceptor."

Troublesome radar

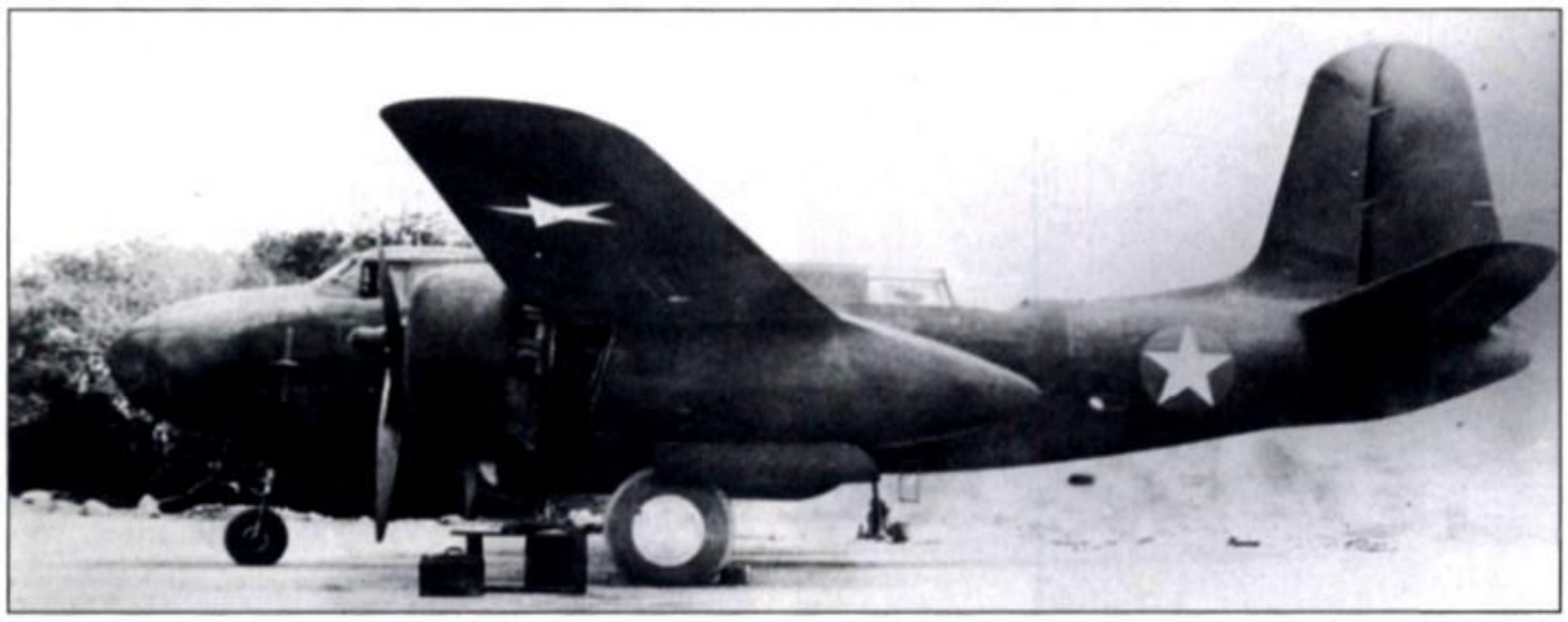
Radar proficiency was another matter entirely. It did not take long for the night-fighter pilots to realise that the P-70 was not an interceptor-type aircraft. After all of the training and the long trip from the US, it was a tremendous letdown to learn that, regardless of radar assistance, the aircraft just would not deliver. Then, to the dismay of all concerned, it was found that the radar was almost useless below 5,000 ft (1524 m) due to ground scatter and interference. Also, at about 10,000 ft (3048 m), the radar equipment very often was rendered useless because of air pressure problems.

F/O Paul DiLabbio, one of the more experienced radar observers, noted, "The Mk IV radar was limited in range to approximately 21,000 ft (6400 m) and roughly about 40 degrees in elevation. One of the most important things needed to make all of this work was co-ordination between members of the aircrew. First of all, the pilot had to be exceptionally good on instruments, and in the 1943-44 period there were not too many of them around. Secondly, the R/O had to be the eyes of the pilot. If you want to experience what I am trying to convey, just get in the back seat of an automobile and try to give instructions to a blind-folded driver; only, with an airborne R/O you will throw in an additional dimension – altitude! It was very tough during those early days, but by the time the Black Widow became operational, we not only had the experienced aircrews, but the best night-fighter ever built."

The problems that the 6th suffered went far beyond its aircraft. There was not a single defence command or commander, so all of the defence forces on Guadalcanal acted as separate units. The night-fighters had their ground station, the anti-aircraft batteries had their 90-mm guns. If the searchlights locked on to enemy bombers overhead, the batteries began blasting with little or no regard for any friendly night-fighters that might be in close pursuit. Many pilots stated that it was disheartening to fly through their own flak in an effort to make a kill, and especially since the AA guys had not shot down a single Japanese aircraft to date.

First blood

In the early morning hours (04.30) of 19 April 1943, the P-70 got its first kill – and it was spectacular. The troops around Henderson Field did not get much rest, so they were usually up several times during the night, until the air raid sirens signalled the all-clear. On this night, the 'Betty' bombers were spaced so that most of the personnel were up and watching the AA attempt to bring one down. It was like a football game, with a packed stadium. Captain Earl Bennett and his R/O Corporal Edwin Tomlinson were patrolling the perimeter when they locked on behind one of the Japanese bombers as it made its bomb run over the island. Anything moving in the air was fair game to the gunners on the ground, and Bennett's P-70 stayed on the tail of the bomber



Left, below left and below: P-70s on Guadalcanal. The night-fighters were welcomed by the Marines on 'the 'canal' who had endured months of night attack and harassment. On the other hand, little provision had been made for their arrival and Detachment B had to scrounge what creature comforts there were to be found from other units on the island. Initially based at Fighter Strip 2, the P-70s soon moved to Carney Field where their ground radar station – named 'Kiwi' – was set up. 'Kiwi' was an offshoot of the established system and, as such, aircrews and controllers had to learn co-ordinated operations as they went along. Different terminology and poor communication led to many kills being missed and some close shaves with 'friendly' AA fire. Nevertheless, two enemy bombers were destroyed and the Japanese were forced to change tactics, reducing their effectiveness.

as it came over Guadalcanal, right through the AA. The spectators on the ground could see the tracers from the night-fighter as they found their mark all over the fuselage of the Japanese bomber. It exploded in a spectacular ball of fire and the Marines on the ground cheered like it was the winning goal. The 'Betty', encased in its own fireball, plummeted to the ground.

Change of tactics

This was an example of a gross miscalculation on the part of the Japanese. They knew the P-70s had been trying to intercept them and it was obvious that they did not consider the American night-fighter a serious threat, because they made their bomb run at a much lower altitude than was customary. In the weeks that followed, the P-70s had no chance of any successful intercepts because the enemy kept their altitude in the 28,000-ft (8534-m) range.

It was this vast difference in operational altitudes between the P-70 and the 'Bettys' that prompted the decision in mid-June that P-38s would assume the role of primary night-fighter. This was a good news/bad news dilemma. No one was enthusiastic about breaking up the well trained pilot/radar observer teams. On the other hand, it would be a great boost in morale to see the high-flying P-38s climb up to the altitude of the 'Bettys' and bring down a few!

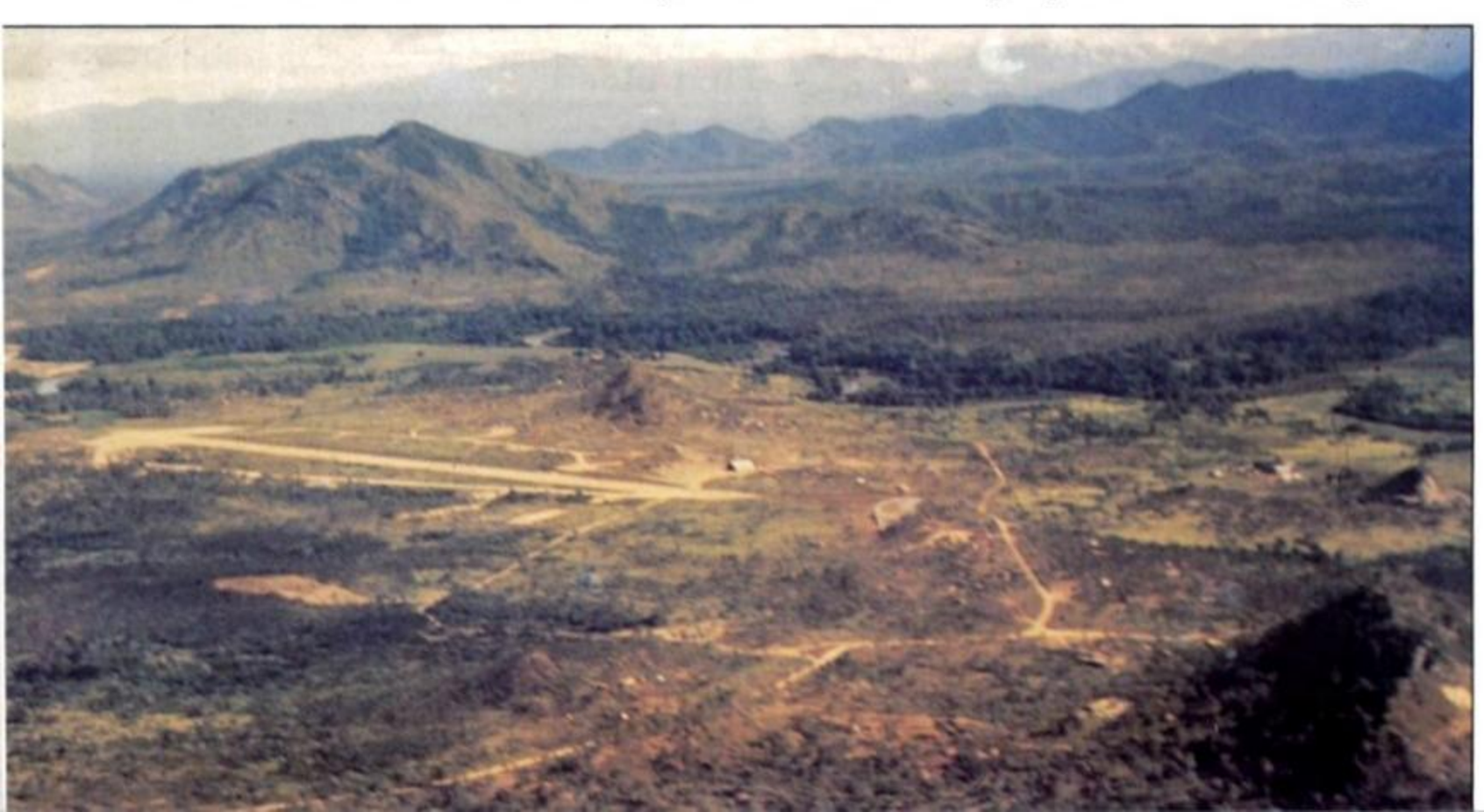
The P-38s made a lasting impression on the Japanese aircrews. Four enemy aircraft were shot down in a 30-day period, which altered the frequency with which these bombers came down the slot. Their strategy changed because the P-38s could match the Japanese at any altitude. The new tactic involved the 'Bettys' coming over Henderson Field at a very low altitude and full throttle, dropping their bombs and getting out quickly. It proved to be satisfactory for them and they stuck with it for some time.

Admiral Halsey and Admiral Nimitz both continued to put pressure on the Pentagon for a night-fighter that could operate at 30,000 ft (9146 m) and had a speed of 350 mph (217 km/h). Although top secret at this time, the Northrop P-61 was well on its way to production. In the meantime, the P-38s with searchlights worked the high-altitude missions, while the P-70s stayed at lower altitudes. Their performance was very commendable at 15,000-18,000 ft (4572-5486 m).

Night battle

On 15 May, the P-70's 20-mm cannon struck again; this mission might have been the one to put the underpowered night-fighter in the record books. Lieutenant Burnell W. Adams and his R/O Flight Officer Paul DiLabbio were on a routine patrol between Henderson Field and the 'Slot'. If there was any enemy activity, it would have to come through them. F/O DiLabbio said, "I picked up the first bogie at 18,000 ft. (They usually came in at 28,000 ft or higher.) This was an exception and it proved to be a fatal one – for the Japanese. We were at 26,000 ft, so the incoming bogie was quite a bit lower than we were. I gave Lieutenant Adams directions to dive down and turn to port. It was about this time that our intercom started malfunctioning, but not before I was able to give one more set of instructions to Adams – to level out the dive and steady the heading. Immediately, Adams told me he had a visual contact and seconds later I heard the 20-mm being fired. Adams scored several hits and the bomber exploded.

"We identified it as a 'Sally' [Mitsubishi Ki-21]. While Adams was firing, I picked up the second bomber and had him pinpointed,



While Detachment B was having a fair measure of success on Guadalcanal, the second element of the 6th NFS were getting established on New Guinea. This is 12-Mile Strip, hewn out of the jungle near Port Moresby.

Despite its lack of modern conveniences, 12-Mile Strip was a good base for the P-70s, having an adequately long runway and being far enough away from hills for safe night operations. Here, a P-70 taxis out for a daylight test flight.

but the intercom was completely garbled and I could not pass the info on to Adams. I firmly believe we could have got two kills that night if not for the intercom problems! We later learned that the Japs were monitoring our communications and from then on they never came in below 28,000 ft."

Second detachment

When Detachment B was sent to Guadalcanal, plans were already in the works to send another group to New Guinea. From the early planning stages, they were referred to as Detachment A. On 19 March 1943, the small group began its long island-hopping flight from Kipapa Airfield to Port Moresby.

It was composed of the same number of aircraft as its sister detachment: six P-70s and two LB-30s. The night-fighters had been fitted with additional fuel tanks in the bomb bay, for this flight would be at least 1,500 miles (931 km) farther than the movement to Guadalcanal. The flight plan dictated that one LB-30 be positioned in front of the formation and one positioned to the rear, to keep the fighters together during periods of bad weather with very low visibility.

6th NFS pilot Lieutenant Fred Secord's logbook showed the following data concerning the flight to New Guinea: 19 March – Kipapa, Oahu to Hickam Field; 20 March – Hickam to Hilo; 22 March – Hilo to Christmas Island (1,400 miles/869 km with a flying time of 6 hours 45 minutes); 23 March – Christmas Island to Wallis Island (500 miles/310 km with flying time of 3 hours); 24 March – Wallis to Nandi (time of 2 hours 40 minutes); 27 March – Nandi to New Caledonia (time of 4 hours 30 minutes); 28 March – New Caledonia to Brisbane, Australia (1,000 miles/1610 km and 4 fours 30 minutes); 29 March – Brisbane to Townsville (800 miles/1287 km and 3 hours 25 minutes); 1 April – Townsville, Australia to Port Moresby (700 miles/1126 km).

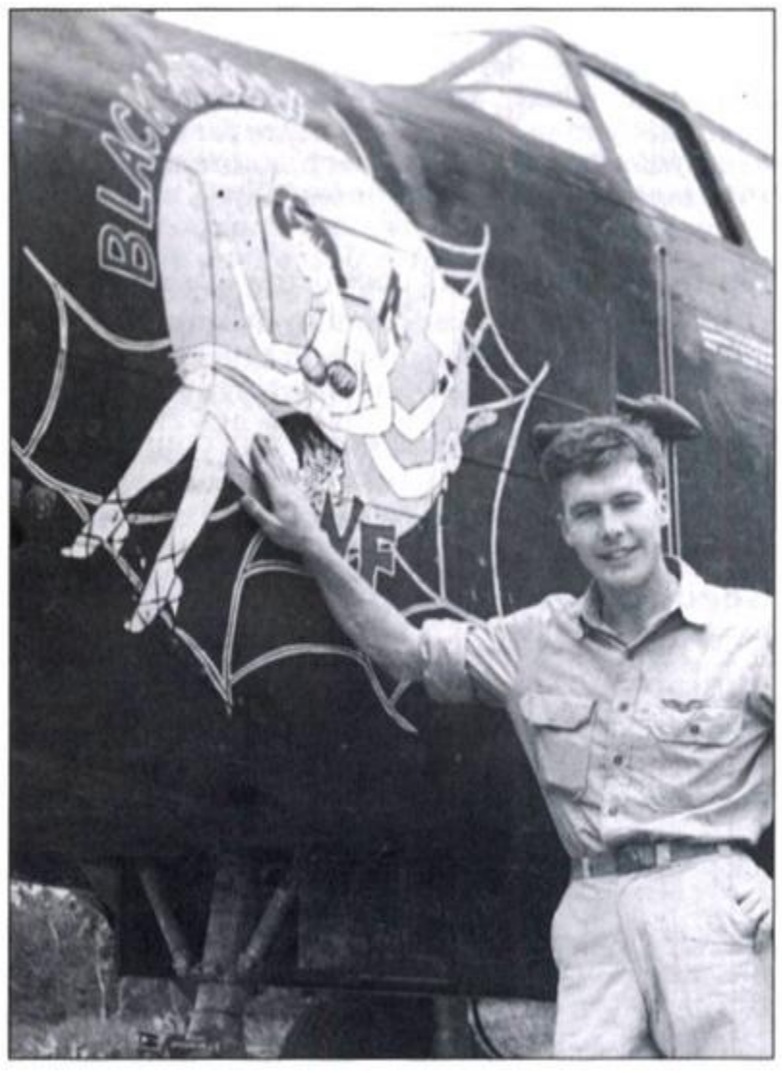
The flight over water went smoothly, and the only mishap was encountered during the final stage of the flight. Lieutenant Secord had to make a wheels-up landing at Townsville. He remembered the incident: "It was on approach to Townsville that I encountered a problem with the nose gear – it would not extend. We tried bouncing the plane hard on the gravel runway, hoping to dislodge the gear. That was unsuccessful, so we did half a loop, then inverted flight, and all got no results. Finally, we had to make a decision to either bail out or bring it in with wheels up.

Above: The commanding officer of Detachment A, Captain Robert McLeod, watches as one of his aircraft undergoes an engine change at 3-Mile Strip. In the absence of the jacks, cranes and hangars of stateside bases, aircraft maintenance was often a matter of applying as much manpower as possible to a problem.

Right: After its adventures in Australia, Secord and Hale's P-70 caught up with the detachment in New Guinea. The name* Dusty *was applied after the belly landing at Townsville.

Below and bottom: Many of the Detachment A aircraft were decorated with variations of this badge depicting a black panther on a jungle branch. Behind Lt Secord, seen here admiring the artist's work, is one of the receiving aerials for the British AI.Mk IV radar set. The transmitting aerial was on the tip of the nose, as seen in the lower photo with another version of the badge.

Posing with one of the unit's P-70As are members of Detachment A. Left to right: Lt Secord, Lt Hale, Dr Ralph Cantafio (flight surgeon), F/O Cavelli and Lt Utley.



Captain Robert W. McCleod, seen here with the same aircraft shown at left, became detachment commander when Captain Warren Hornaday and his radar operator were killed on a training flight.

"It had already been proven that if you landed a P-70/A-20 on its main gear only, the nose would dig into the ground at about 70-80 mph (112-128 km/h). The result would be a sprung fuselage frame and an irreparable aircraft. Since our P-70s were very scarce and extremely valuable to the war effort, we elected to land wheels up. The gravel seemed to act as small ball bearings and, although both props were bent and the 20-mm gun tub was damaged, the airframe was in good shape. Several bushels of gravel were scooped up into the rear hatch and the aircraft came to rest in a cloud of dust. It was this incident that caused us to name our ship *Dusty*. The repairs on my fighter began immediately, but the rest of Detachment A left for Port Moresby and the war."

The 6th's detachment made its home at Three Mile Strip on the coast of New Guinea. It got its name from being 3 miles (5 km) from Port Moresby. 5th Fighter Command, under Brigadier General Paul B. Wurtsmith, would be calling the shots for the P-70s and they would be getting plenty of air time.

Throughout September and November, the Japanese were relentless in their efforts to kick the Marines off Guadalcanal. Their ships would steam down the 'Slot' every night, and, while the cruisers and destroyers were shelling the Americans, the Japanese troop ships were attempting to unload reinforcements. The US Navy went after enemy shipping that would be carrying troops and supplies. When this effort became too costly, the Japanese started using barges and hugging the coast line of the many islands around 'the 'canal'.

Barge busting

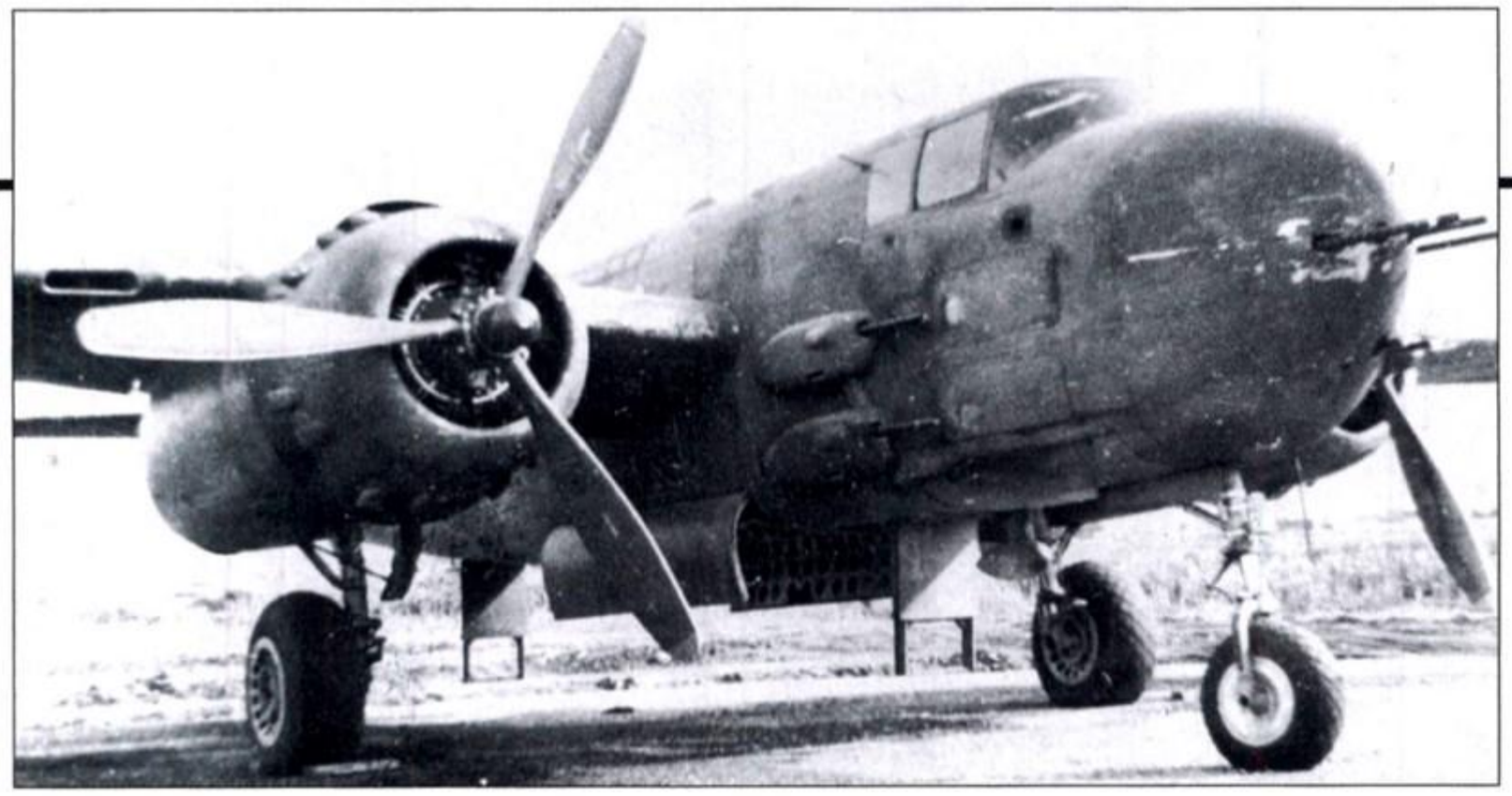
This strategy was countered by the aggressive American PT boats. They would sit and wait for the supply barges then, like a coiled snake, they would strike and be gone. As this was a desperate tactic by the Japanese, there was no other course but to defend the barges, which was done with floatplanes and flares. When the PTs made their move, the enemy aircraft would spot them, drop flares and then make several strafing passes. That was when the P-70s were called in: their assignment was to keep the floatplanes away from the PT boats. A small problem was that the slow-moving floats had a speed of 100 mph (62 km) and the P-70 close to 270 mph (167 km), and the Japanese aircraft had the advantage in manoeuvrability.

On the night of 16 August 1943, 6th NFS pilot Lieutenant Jack Bradner and his R/O Flight Officer Willie Coleman took off on a mission to cover PT boats that would be operating in the Ferguson Passage area. This was to be a 'set-up' to lure one or more of the Japanese fighters up. The PTs made a 'bogey bait' run through the passage, but no enemy fighters came out. Bradner recalled that mission. "Since no fighters came up, the next step was to have the PT boats rake the Kolombangara coast with 0.50-in calibre fire. Soon after the shelling, a single-seat float biplane lumbered into the vicinity. As the Japanese pilot lined up for the strafing run, I came in at full throttle for a 90° deflection shot without any visible results. Seconds later, at point black range (150 ft/45 m), I boresighted the enemy fighter, but only one of my 20-mm fired. The float did a fast split-S and shot back. Contact was then lost.

"All of this action took place at an altitude under 2,500 ft. The weather was good, with visibility at 3 miles. I was sure I had got him. One of the PT commanders stated that he had

Right: Another fine example of the nose art found on aircraft of Detachment A was* Stygian Pigeon*, seen here with Flight Officer Cavelli, a squadron radar operator. The unit used a mix of P-70s with the 20-mm cannon tub and P-70A-1/2s (converted A-20C/Gs) with six or eight machine-guns in the nose.

Left: The 'Hoot Owl' badge was the unofficial insignia of the 6th NFS from the introduction of the P-70 until the end of the war. It was personally designed for the squadron by Walt Disney.



P-70 in the Pacific

With diminishing Japanese air opposition, the night-fighter squadrons began to adopt the night intruder role themselves. The 418th NFS on New Guinea traded in some of its P-70s for B-25Hs, which could bring far more firepower to bear on ground targets.

seen the aircraft go down, but I never received credit. However, it didn't matter, because the effect of this encounter was profound. From that night on, the floats didn't came out to bother the PTs again!"

One of the weaknesses in the system was communications. It was too early in the war for the streamlined consolidations that would come later, and too many jobs were being done on an independent basis. Captain John Florence, a pilot in the 6th, related one of them. "I can recall several incidents where communications left a little to be desired, but one in particular stands out. We were getting many new ground controller replacements. Their training course in the States had changed some of the nomenclature, particularly changing left and right to port and starboard. We, in New Guinea, knew nothing about this.

"This episode pertained to a Japanese bomber that was coming over Dobadura at a very low altitude, due to thunderstorms in the area. It would be the only chance that I had for a 'kill'. Because of the storms, radio static caused reception to be worse than usual. Also, my time around Navy types was limited, so I was not up on all the jargon. Up until now, the ground controllers had directed us with right and left, but a new controller was on duty. He told me to turn 180° port. With the poor radio reception, I gambled that the time necessary to find whether he meant right or left would lose any chance I had at closing, so I turned right 180°. Needless to say, we educated the ground controllers in the Air Corps terminology: right and left!"

The Pacific war was gradually starting to move to the east and Japan. The first stepping stone (Guadalcanal) was in place. At home, war production had finally built up enough to get some valuable equipment and supplies to the troops in the Solomons. The European Theatre still had top priority, but the lopsided gap was beginning to narrow.

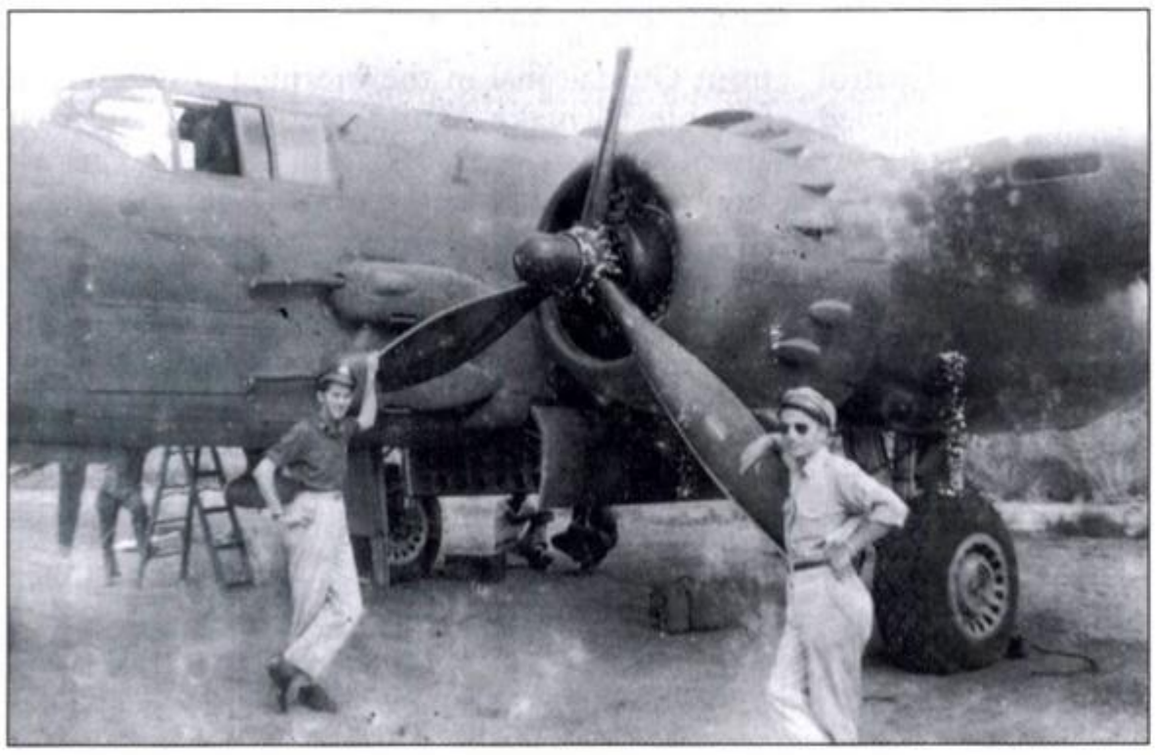
It was obvious that two detachments of P-70s from the 6th could not cover the new bases that would be needing night protection, in a few short months. On 6 October 1943, the 418th Night Fighter Squadron departed from the US on the USS *General John Pope*. They arrived at Milne Bay, New Guinea on 6 November. There were not enough P-70s dedicated for operational use to cover the new night-fighter squadrons that were in training.

Aircraft shortage

This shortage of aircraft was evident when the 6th NFS's Detachment A, on New Guinea, turned over all of its assets to the 418th (five P-70s and two P-38s). The outlook brightened somewhat when seven more P-70s were flown from Brisbane to allow the 418th to spread its aircraft over a wide area. Some of the bases considered to be within its area of responsibility were Dobadura, Port Moresby, Kiriwina Island, and Finschhafen. The 418th NFS was the first night-fighter squadron to be activated and trained in the States and sent to the Pacific Theatre.

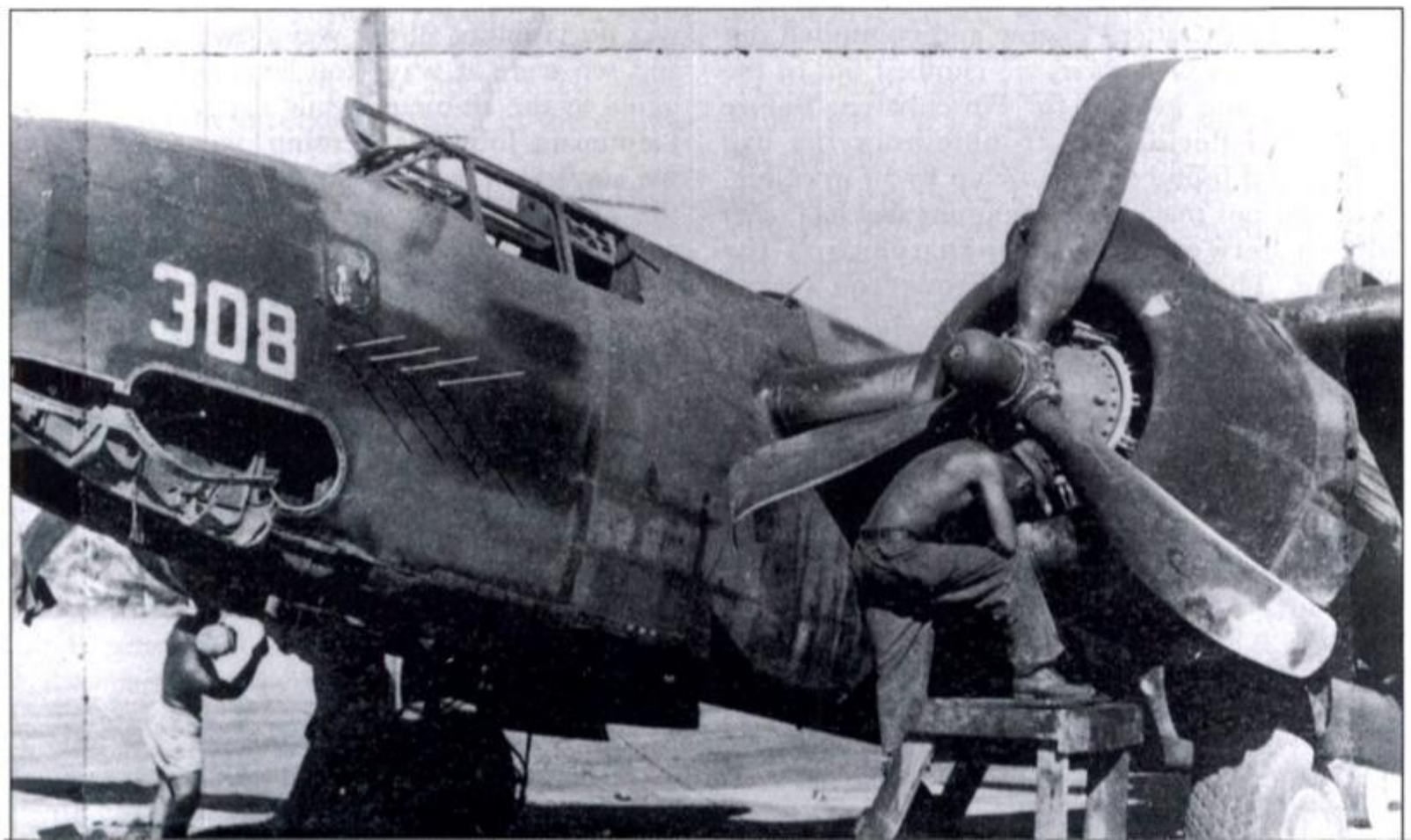
The war was spreading over a massive area and each island that was taken from the Japanese was a critical piece to the puzzle, with the final piece being Japan. Until this date, only one true night-fighter squadron had seen a lot of combat; by the end of the war in the Pacific, eight night-fighter squadrons were flying the P-61 Black Widow (not including the two squadrons that saw action in China).

On 26 October 1943, the 419th Night Fighter Squadron departed from San Francisco on the USS *Wharton*, arriving at Guadalcanal's Fighter Strip No. 2 on 15 November. The numbers of aircrews graduating from the intense training courses in the United States was increasing rapidly, and the gap between



Left: During 1944, the 418th NFS operated B-25Hs (shown), P-38F, G and H Lightnings, and P-70s simultaneously before converting to the P-61. As with a number of squadrons, its only kills were scored with 'borrowed' P-38s.

Below: The 419th NFS saw a significant amount of action with the P-70. Aircraft 308 was crash-landed by Lt Donald Dessert at Piva on Bougainville and was subsequently stripped for spares. Dessert later shot down a 'Dinah' after the squadron re-equipped with P-61s.



This spider with lantern and pistol emblem was the unofficial insignia of the 419th NFS, active on Guadalcanal from November 1943.

Above: The official emblem of the 421st NFS depicted Bugs Bunny wielding a carrot and riding a caricatured P-70.

Left: The 421st NFS was the fourth night-fighter unit to be shipped to the Pacific theatre, where it flew numerous night intruder missions. Lt Carl Bjorum of the 421st is seen climbing aboard his P-70 during the last stage of advanced training at Kissimmee, Florida before the squadron was sent to New Guinea.

qualified people and available aircraft was widening. The 419th brought 15 pilots, 13 R/Os, 12 gunners and 232 enlisted personnel with it. They shared equipment with the battle-seasoned Detachment B of the 6th NFS, which had been handling the nocturnal responsibilities in the Solomons since 28 February. Between these two units, there were only three P-70s and eight P-38s. In the weeks to come, the 419th got plenty of experience working the night intruder mission with the P-70, for which it was well suited. The high-flying P-38s continued their job as the high-altitude interceptor.

Colonel Carroll Smith, the sole ace to emerge from the Pacific in night-fighters, and commanding officer of the 418th, explains how the P-38 operations supplemented the P-70. "By January 1944, we were operational in both the P-70 and P-38. Aside from local area patrols in the '70 during night time or periods of inclement weather (whenever the day fighters could not fly), our principal task was P-38 patrols out of Finschhafen.

P-38 operations

"A typical mission was to depart from Dobadura in the afternoon, stage from Finschhafen and relieve the day fighters patrolling the Madang and Alexishaven area, so they could land before dark. We would patrol in two ships with P-38s all night until relieved by day fighters after dawn. Usually our shift was uneventful. I shot down a 'Val' [Aichi D3A] during this period, over the Alexishaven air strip, with Captain Harold Whittern as my wingman. The Japanese were tricky – on one occasion we made a pass at three 'Sallys' parked on the airfield, only to find, when we got close enough, that we had been suckered! The 'Sallys' were wrecks being used for bait.

"I yelled to 'Whit' that I had let us get suckered and for him to get as low as possible – I was so low when the shooting from both sides of the airstrip started that the Japanese were almost shooting at each other and 'Whit' was under my wing! As we cleared the field, I felt an explosion in my left engine nacelle. I quickly feathered the injured engine and continued out to sea. When well clear, we climbed out of the salt spray and headed for Finschhafen. Before landing, I decided to troubleshoot the bad engine and found it ran OK up to 30 in of Hg. It turned out that only a neoprene seal had been blown between the turbocharger and the engine. The morale of our squadron soared with the 'Val' kill."

Both detachments of the 6th NFS were absorbed and replaced by the 418th and 419th squadrons. The 6th pulled back to Hawaii and awaited the new P-61 Black Widows. When World War II ended and the P-61 had become legend, the 418th ended up as the top-scoring night-fighter squadron in the Pacific Theatre (in the P-61), with 18 kills. The 6th was next, with 16 kills. Their preparation and training in the P-70 had been invaluable.

The low-level intruder mission in the P-70 was more dangerous and exciting than working with GCI, at altitude, on an intercept. According to Lieutenant Al Lukas, one of the most experienced night-fighter pilots in the Pacific, it was the ultimate high. Lukas had served in England with RAF night-fighters before joining the 419th. He recalled one mission where all hell broke loose on a very long night intruder mission against the Japanese fortress at Rabaul.

"This mission would probably be a hairy one. It was going to be the first 'on-the-deck' night raid attempted against a heavily defended Rabaul. I made sure that my regular crew would be on this one with me. We took off from Guadalcanal in the morning so we would be able to make Munda by noon. Late that afternoon, we took off again for Torakina air strip on Bougainville, making it right after dark.

"This put us in position for our 23.00 take-off for the target. We took off on schedule, hugging the western coast of Bougainville towards Buka Passage. Skimming along at wave top, in the moonlight, we made Cape St George as planned and I set our course of 115°. Moments later, S/Sgt DeForrest, my gunner, yelled out, 'Bogey above and astern, a 'Dave' [Nakajima E8N] floatplane!' We were in a perfect position to knock it down, but he hadn't seen us and that wasn't why we were out there. As we moved away, we kept a close eye on him.

"Proceeding along the west coast of New Ireland, we hit some heavy rain squalls. There was no visibility all the way down to the water and we were at wave-top level. My eyes were glued to the altimeter while my radar operator, Lieutenant John Blankenship, was making sure we stayed away from land. On New Ireland, the old volcanoes were 3,700 ft high near the coast, peaking at 6,000 ft. We hit Cape Gazelle, which was the wrong place – turned around and headed for New Ireland, leaving the bad weather behind us.

"We hit our checkpoint at Duke of York and set a course for Watom Island, our most important checkpoint prior to our final run toward Rabaul. Minutes later, we were over the Vera Vera Plantation, right on the deck now, at full throttle. The plantation was exactly like the aerial photos we had seen. Final course set – throttle still wide open, climbing as the terrain rose to the crater's edge (the island of Rabaul is a huge crater, with the centre a deep

P-70 Variants

XP-70
Revised A-20 prototype with the R-2600-11 engine and solid nose
Crew: two
Armament: four 20-mm cannon
Used British AI.Mk IV radar
Gross weight: 20,980 lb (9536 kg)
Total built: 1 – A-20 39-735

P-70
Converted A-20s with radar in nose
Gross weight: 21,000 lb (9545 kg)
Total built: 59

P-70A-1
Modified A-20Cs
Armament: six 0.50-in machine-guns in belly
Gross weight: 25,000 lb (11363 kg)
Total built: 39

P-70A-2
Converted A-20Gs
Armament: six 0.50-in machine-guns in nose
Gross weight: 25,300 lb (11500 kg)
Total built: 65

P-70B-1
Converted A-20G-10 with SCR-720 radar in nose
Armament: three 0.50-in machine-guns housed on each side of the forward fuselage
Gross weight: 25,000 lb (11363 kg)
Total built: 1

P-70B-2
Converted A-20G and A-20J airframes
Used SCR-720 radar
Armament: six to eight machine-guns (sometimes retaining dorsal turret)
Gross weight: 25,000 lb (11340 kg)
Total built: 105

Performance (P-70): maximum speed 329 mph (529 km/h) at 14,000 ft (4267) m; climb rate eight minutes to 12,000 ft (3658 m); service ceiling 28,250 ft (8611 m); combat range 1,060 miles (1706 km)
Weights: empty 16,031 lb (7272 kg); maximum take-off 21,264 lb (9645 kg)
Dimensions: span 61 ft 4 in (18.69 m); length 47 ft 7 in (14.50 m); height 17 ft 7 in (5.35 m)

Above: The old and the new – one of the original P-70s poses with a P-61 over California for a publicity shot. The pack containing the four 20-mm cannon can be seen clearly on the underside of the P-70. The Black Widow was equipped with a similar, but more streamlined, installation from the outset.

Left: On the basis of combat victories alone, the P-70 programme could be described as a failure. However, this converted bomber and its crews did much to establish the principles of night fighting within the USAAF. In the training role, the P-70 was the schoolhouse for the vast majority of wartime army night-fighter crews.

harbour that can accommodate a large number of ships). Over the ridge now and there was the harbour, with our P-70 exactly where it was supposed to be!

"I dropped the nose and headed down for the line of docks and Japanese naval vessels, fuel dump, the Chinatown area and the formerly elegant British hotel, the Australia House. The Australia House was now headquarters for the Japanese high command. I had planned to drop my four 100-lb HE bombs and 60 4-lb packets of incendiaries about half-way down the long dock area. My airspeed was over 300 mph and we were as low as we could go! My bomb load was away and everything was a blur as we shot across the target area. The load hit perfectly on the docks and continued right on through the fuel dump – and into Australia House. Blankenship yelled out, 'The bombs are going off, one building just rose up and fell apart! There goes the incendiaries, right in the middle of the dump!'

"Visibility over the harbour had been 1/10, perfect, with cloud ceiling at about 900 ft. Searchlights began to come to life, but we were below their probing fingers. At full speed, and climbing to clear the crater, we headed for Laveo Point. Behind us, scores of searchlights waved frantically amidst the glow of a burning fuel dump. As we approached Cape St George, we spotted the well known Japanese radar installation that had shown up on so many of the recon photos. I called back to my gunner and asked what he thought about making a couple of passes on the site. 'Let's go!' was his enthusiastic reply.

"I circled back to make an east-to-west run on the deck, strafing with my forward 50s as we came in. Just as I pulled up, DeForrest let them have it from his rear 30s. Another pass and our ammo was exhausted, but the radar site was in shambles. We climbed up to 9,000 ft for the flight back to Torokina. We touched down at 03.00, four hours after we had taken off, low on fuel and out of ammo. It had been one of the most gratifying missions I have ever flown."

This mission was flown in s/n 269, one of the P-70s not equipped with the 20-mm tub.

New squadron

On 5 December, the fourth night-fighter squadron to be sent to the Pacific Theatre sailed from San Francisco on the USS *Sea Perch*. Thirty days later, the 421st NFS arrived at Milne Bay, New Guinea. It was sent into combat quickly, operating out of Nadzab. Its biggest problem was the lack of aircraft, for they started out with only two P-38s. The attrition rate on day fighters was significant, but, in proportion, the night-fighters suffered more severe operational problems because they did not have enough aircraft.

After six weeks in the forward areas, the 421st NFS finally received its first P-70. Unbelievable as it may sound, it was not until 29 February that the squadron was able to log its first combat mission. The 421st continued to operate, under the crudest of conditions, from Nadzab, New Guinea, until May 1944. At that time, new life was injected into the squadron when it moved to Biak Island in Dutch New Guinea. This move brought about the phasing-out of the remaining squadron P-70s and the reception of 12 new P-61A Black Widows.

As the years pass since the end of World War II, the memory and knowledge that there ever was a P-70 have dimmed considerably. This is only natural, because the war was not going well when the converted night-fighter was thrown into the fray. As the momentum of the war changed and it became evident that the Allied forces would be victorious in all theatres, the P-61 came on the scene. It was a highly publicised, state-of-the-art night-fighter that had been designed specifically for the role. No German or Japanese aircraft were immune to the Spider's sting.

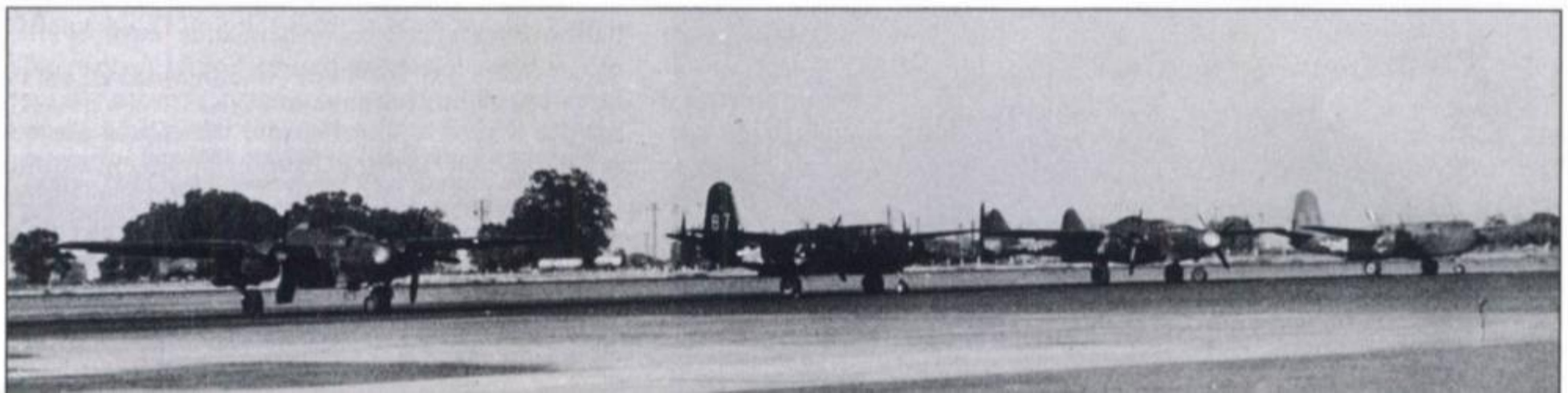
Stopgap fighter

The Douglas P-70 had been a true stopgap fighter and it did a superior job, considering it lacked the speed and altitude performance of some enemy bombers. The Japanese bombers were relatively safe when they flew above 28,000 ft (17391). The A-20 Havoc series was built for and had an excellent reputation as a fast, low-level bomber. It was never meant to be effective at 30,000 ft (18633 m).

The high-flying P-38 teamed up with the P-70 to become the high/low duo. This seemed to work well and it bought valuable time in an area where the Americans were very weak: defensive night-fighting.

By the time World War II ended, the first four night-fighter squadrons to fly combat in the Pacific (6th, 418th, 419th and 421st) had racked up an astounding total of 52 confirmed night kills, most of which were in the P-61.

Warren E. Thompson



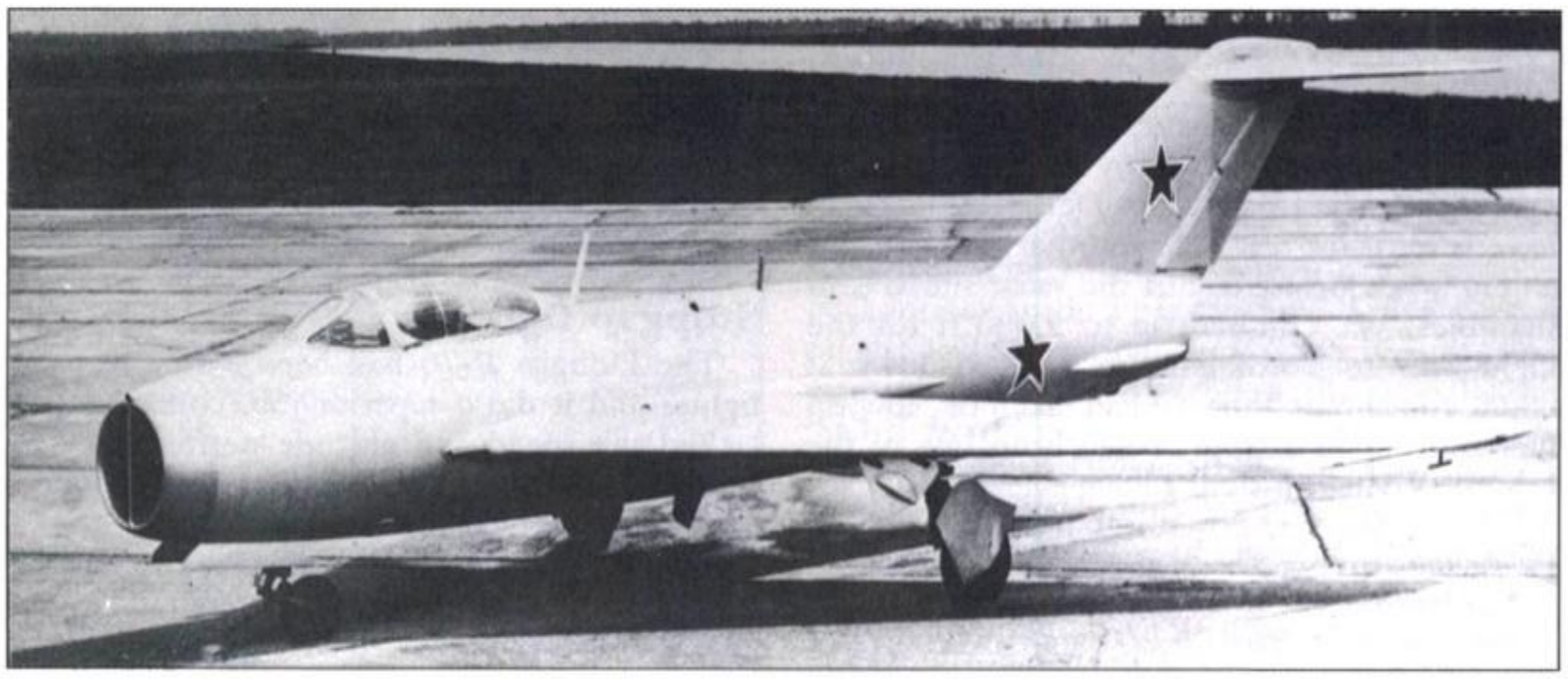
The 547th NFS was activated in California on 1 March 1944 with P-70s. In September it moved to New Guinea with P-61s and was active in the Philippines and Japanese home islands, scoring seven kills. The squadron is seen here during the transition between types.

Mikoyan MiG-19 Variant Briefing

Supersonic Soviet

When the famous American test pilot Frank K. Everest referred to the USAF's first supersonic fighter, the North American F-100A Super Sabre, as the best tactical fighter, he had no idea the Soviet answer to the F-100 was already well into its test programme on secret air bases in the USSR. The MiG-19 (and the Chinese-built J-6) was to become a true global warrior, seeing action in the hands of many air arms, and spawning many variants.

Perhaps the best-known 'Farmers' are the Shenyang F-6s supplied to the Pakistan Air Force. This pair is from No. 23 Squadron; the far aircraft carries an AIM-9P Sidewinder, just one of the Western systems fitted to PAF aircraft.



The first aircraft to carry the MiG-19's 55° wing was the SM-2 (also designated I-360), which first flew on 24 May 1952. It achieved Mach 1 in level flight later that year. The first YF-100A Super Sabre did not fly until April 1953.

In many ways the 'forgotten' MiG, the MiG-19 bridged the gap between the pugnacious MiG-17, which was built in huge numbers, and the ubiquitous MiG-21. Production was limited by the Soviet standards of the day – reaching around 2,000 examples – and there were only four major operational variants. However, the airframe was the subject of much experimentation, resulting in a large number of other variants. Together with the operational variants, these trials machines were instrumental in taking the Soviet air force from the subsonic, gun-armed day-fighter era into the supersonic 1960s world of radar and missiles.

Initial production was of the basic MiG-19, which was hastily produced to provide supersonic capability at minimum notice. The key to the aircraft's enviable performance (easily eclipsing that of the contemporary F-100) was the thin high-aspect ratio, sharply-swept wing. Apart from minor aerodynamic improvements, such as larger fences, the wing remained little changed, and proved to be something of a masterpiece right from the start.

Initial MiG-19 production was quickly superseded by that of the MiG-19S, which addressed many of the handling problems of the first production aircraft. These problems were symptomatic of the abbreviated development programme required to field an operational aircraft hastily, and were soon rectified.

MiG-19s went into service with the PVO as interceptors, and subsequent Soviet development was largely to follow this path, leading to the radar-equipped MiG-19P, and finally the MiG-19PM with radar and missiles. As the Soviet Union's first supersonic-capable fighter, the MiG-19 also became the subject of many test programmes, many of which would lead to features of later production fighters. A myriad of experimental aircraft tested refuelling, new launch and recovery techniques, extreme-altitude potential, new weapons and revised intakes and propulsion systems.

In China the basic MiG-19S day-fighter was built in vast numbers (over 3,000) to form the backbone of the People's Liberation Army Air Force, a position it still holds today (at least in numerical terms). Chinese development accounted for several new variants, while the type was widely exported from both Soviet and Chinese sources.

Although rapidly supplanted in PVO service by more capable types, the MiG-19 was to enjoy a very long career elsewhere. Appreciated for its no-nonsense sturdiness and impressive performance, the MiG-19/J-6 was involved in much action, including Cold War confrontations, cross-border skirmishes and full-blown wars. This long combat record, compiled in many corners of the world, is briefly recorded below.

USSR activity

Of the approximately 2,000 Soviet-built MiG-19s, only a handful saw real action and engaged enemy aircraft. The first targets were not actually aircraft but balloons sent across Soviet borders occasionally from Western Europe in the late 1950s. Some were spy balloons carrying reconnaissance equipment, others were loaded with anti-Soviet propaganda literature. The balloons were not an easy target for the MiG-19 pilot because the fighter closed on the slowly drifting balloon at an enormous rate. The pilot had time to fire just a few shots, and even then the shells merely pierced the thin skin of the balloon. The damn balloons took a lot of killing – they did not burst but just

deflated slowly, so the pilot had to expend almost all of his ammunition to make sure the intruder was shot down.

If the balloons were not an easy target, the MiG-19 stood no chance at all against the Lockheed U-2, which was to become the PVO's *bête noire* in the late 1950s. Starting in July 1956, U-2s intruded into Soviet airspace more than 30 times, taking thousands of pictures of Soviet military installations.

The first encounter between the MiG-19 and the U-2 was in the autumn of 1957 in the Turkestan defence district, when a squadron leader of the 9th GvIAP (GvIAP = *gvardeyskiy istrebeetel'nyy aviapolk* – Guards fighter regiment) scrambled to intercept a high-flying intruder. After climbing to 17000 m (55,775 ft) the pilot reported sighting a 'cruciform aircraft' – undoubtedly a U-2 – flying around 3000 m (9,840 ft) higher. Shortly afterwards, the PVO C-in-C, Colonel General Yevgeni Ya. Savitskiy, visited the unit and, upon hearing the pilot's report, stated that the pilot was "seeing things" because the adversary had no aircraft capable of flying that high! The pilot was transferred to another unit soon after. (Moral: if you can't shoot it down, it doesn't exist.)

Further attempts on the 'Angel'

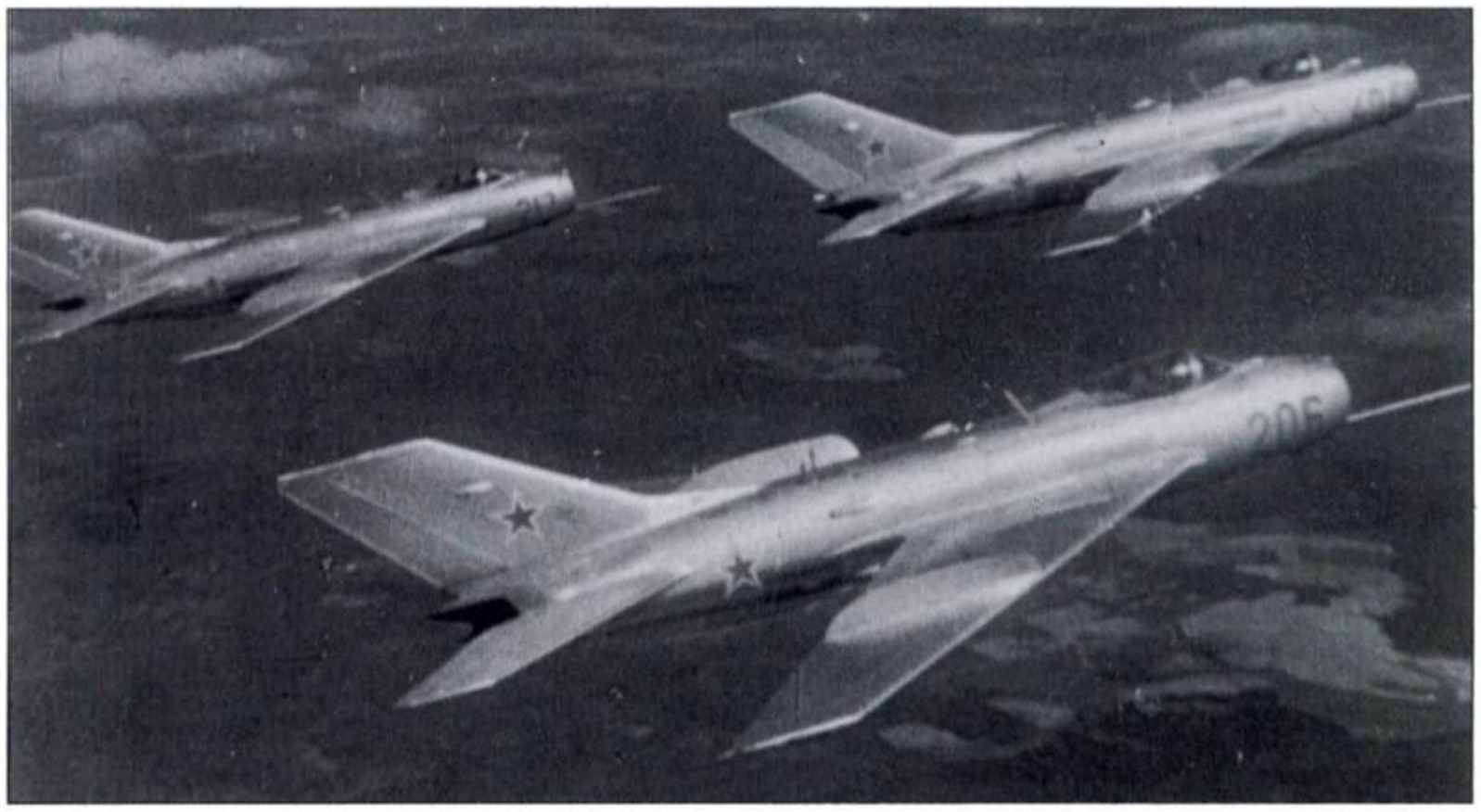
On 9 April 1960 the 'non-existent' aircraft flown by none other than Francis Gary Powers popped up again in the same area. Taking off from Peshawar air base in Pakistan, the U-2 crossed the Soviet border near the town of Maryy (Turkmenia) and headed for the Baikonur space centre in Kazakhstan. A flight of four MiG-19s scrambled from Andizhan but failed to spot the enemy at 16000 m (52,495 ft). Two more MiG-19s, this time 356th IAP aircraft, took off from Sverdlovsk (now Yekaterinburg), planning to make a refuelling stop at Orsk air base and intercept the U-2; however, Lieutenant (sg) V. Karchevsky crashed on the approach to Orsk and the mission was called off. Meanwhile, the U-2 got away after photographing the PVO training range near Lake Balkhash and the Baikonur space centre.

On 1 May that year, Powers ran out of luck when his U-2 was shot down by an S-75 Tunguska (SA-2 'Guideline') missile. However, the victory was marred by a tragic incident. Two 356th IAP MiG-19s piloted by Lieutenant (sg) Boris Aivazyan and Lieutenant (sg) Sergei Safronov scrambled to intercept the intruder. Some time earlier another 356th IAP pilot, Captain Mitenkov, took off in a factory-fresh and still unarmed Su-9 'Fishpot' interceptor (of which the unit had only two at the time) with orders to ram the enemy aircraft.

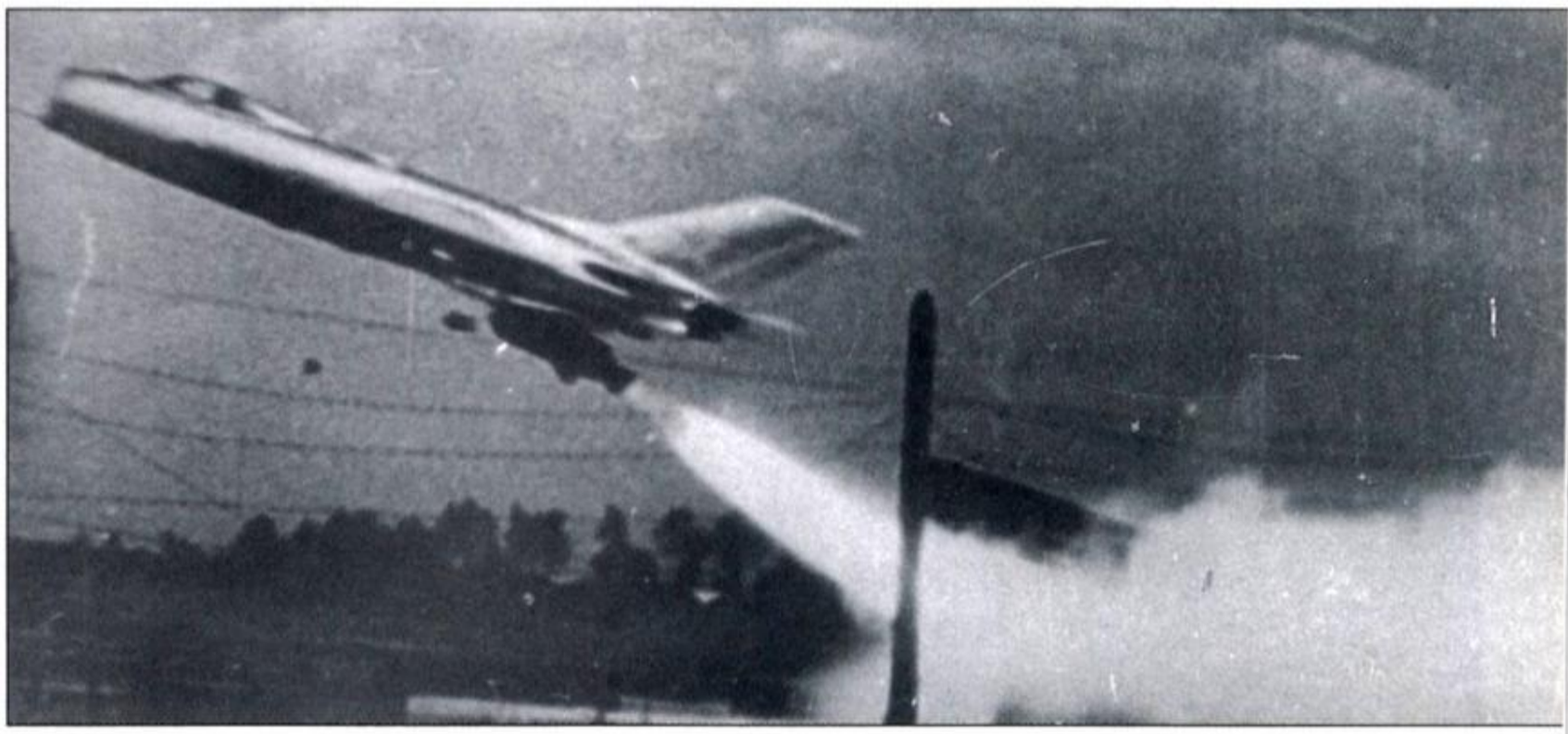
Neither fighter managed to get to the U-2 before it was destroyed by a missile – the first one fired. When the Soviet fighters showed up on the radar screen, a panicked PVO officer mistook them for more enemies and gave the order to fire. Safronov's MiG-19 received a direct hit. The pilot was posthumously awarded the Order of the Red Banner. Aivazyan managed to spot the missile heading for him and went into a vertical dive, causing the missile to lose target lock-on. (Another account of the incident says that Aivazyan had a tendency to show off which, as it turned out, saved his life. On learning that the U-2 had been destroyed he went into a spectacular dive – just for fun – and disappeared from the radar screen.)

Repeated attempts to intercept the U-2 with the MiG-19P/PM were fruitless because at the MiG-19P's service ceiling the target was still well beyond the range of its guns; the heavier MiG-19PM had an even lower ceiling. Even the specially lightened MiG-19SV could stay at 18000-20000 m (59,055-65,616 ft) only briefly and could not manoeuvre at such altitudes in order to make a firing pass at the enemy.

On 1 June 1960, exactly one month after the Powers shootdown, a 55th SRW Boeing RB-47H Elint aircraft crossed the northern border of the USSR near Arkhangelsk. A 171st GvIAP MiG-19 piloted by Captain V. A. Polyakov took off to intercept the intruder, catching up with it near Cape Svyatoy Nos. At 18.03 Moscow time the RB-47 was shot down into the sea, killing the four operators ('crows') in its belly; the two pilots survived.



MiG-19s figured prominently in air displays and flypasts. Several formation display teams operated the type, while formations were seen during military parades. The West's first open glimpse of the fighter was during the 1955 Tushino air parade (below), when three of the initial production aircraft (also shown above) made an appearance.



Like its contemporary the F-100, the MiG-19 was tested with ZELL (ZEro-Length Launcher) equipment under the designation SM-30, using a powerful booster rocket to lift it from a mobile ramp. ZELL was conceived as a means of providing a rapid-reaction point-defence capability for key targets in areas where no airfields existed, or a mobile fighter for use on the European Central Front.

Above: This quartet of MiG-19S fighters wears a red scheme for service with a VVS formation team. The aircraft carry smoke generators under the wings.

Left: Bulgarian MiG-19s were involved in numerous clashes with Greek and Turkish intruders over the Black Sea.

Exactly a month later (again!), on 1 July 1960, Captain Polyakov scored his second victory, shooting down another RB-47. MiG-19S pilots serving with the 24th VA (VA = *vozdooshnaya armiya* – air army, or air force) deployed in East Germany saw quite a bit of action, too. On 20 May 1963, a pair of MiGs flown by Captain L. Shkarooba and Lieutenant (sg) M. Krylov forced down an RB-47 on a Soviet air base; the aircraft was released soon after. On 28 January 1963, a USAF North American T-39 Sabreliner trainer was shot down by MiG-19s, killing all on board. On 2 April that year, a pair of MiGs fired on a Cessna 310 which had strayed outside the Berlin air corridor, forcing it down on a Soviet air base.

On 10 April 1964, a Douglas RB-66D Destroyer Elint aircraft flying along the border between East and West Germany intruded into East German airspace by mistake – or possibly on purpose. By sheer bad luck a Soviet air force MiG-19S was patrolling the area, and the pilot was quick to attack. The Destroyer turned into a destroyee, and the crew bailed out and was taken prisoner. After negotiations at the Presidential level, the incident was played down and the crew returned to the USA.

The swollen upper intake lip and centrebody radome identified the radar-equipped MiG-19P. The radar was short-ranged and unreliable, but did provide PVO pilots with valuable experience in fighting at night or in adverse weather. The armament consisted of just two of the smaller-calibre NR-23 cannon.

In 1968 Warsaw Pact armed forces helped to suppress 'deviations from the socialist course' in Czechoslovakia. Provocative action by NATO aircraft was considered a possibility, so several VVS units, including some equipped with MiG-19Ps from the Karpatian defence district, were deployed to Czech air bases. Soviet ground crews took some time to get there, so for a short while the aircraft were serviced by Polish air force ground crews.

Warsaw Pact users

Outside the USSR, MiG-19s saw considerably more action. Czech airspace was often intruded into by West German and Austrian aircraft. On 12 October 1959, a pair of Czech air force Avia S-105s (licence-built MiG-19S) flown by Jan Bureš and Josef Fajks forced a stray Italian air force Republic F-84F Thunderstreak down on Karlovy Vary airfield. In September 1960 a USAF F-100 Super Sabre was forced down by MiG-19s in what was probably the only combat encounter between the two types. S-105s were in action against balloons as well.

Bulgarian MiG-19 pilots had to deal mostly with Greek and Turkish intruders. Pilot Trifonov, who went on to become a general, had seven aerial victories (aircraft and reconnaissance balloons), some of them in a MiG-19.

Cuba

Cuba was an active operator of the type, using it against CIA aircraft and intelligence ships. On one occasion in the mid-1960s, four Cuban MiGs took off to intercept an intruding vessel but fired on an East German civil tanker by mistake because of erroneous ground guidance. A huge scandal erupted but the Cuban authorities assumed guilt for the incident, saving the pilots from being court-martialled.

Far East

Shenyang J-6 (licence-built MiG-19S) fighters had been the mainstay of China's air defence since the mid-1960s. There were reports that between 1962 and 1964 Chinese MiG-19s had somehow managed to shoot down four U-2s (bearing Taiwanese markings for the sake of camouflage). Of all fighter types in service with

Two PVO MiG-19PMs taxi for a mission. Known as 'Farmer-D' to NATO, the MiG-19PM dispensed with guns altogether, featuring four primitive K-5M radar-guided beam-riding missiles on inner wing pylons.

the PLAAF, only the J-6 had a chance (in theory, at least) of downing the U-2, so the type is given credit for these kills. Yet photos of the downed U-2s displayed in the People's Revolution Museum in Beijing show no battle damage, indicating that the aircraft had force-landed for some reason and were not shot down.

The MiG-19S (J-6) was actively involved in clashes with Taiwanese military aircraft. The first kill (a McDonnell RF-101C Voodoo Photint aircraft) dates to 1964; another was shot down the following year.

Not all sorties were that successful, however. A flight of J-6s attacked a USAF C-130 over the Sea of China. The Hercules radioed for help, and 7th Fleet McDonnell F-4Bs scrambled from their carrier and drove the attackers off. A big battle took place in 1967 when 12 J-6s attacked a flight of four Taiwanese Lockheed F-104 Starfighters; the latter shot down two MiGs with no losses for themselves, getting away from the slower MiGs.

On 21 August that year, four US Navy Grumman A-6 Intruders attacked a North Vietnamese target within 7 km (4.3 miles) of the Chinese border. One pair crossed the border by mistake and PLAAF J-6s appeared promptly, shooting down both Intruders. The crew of the lead aircraft managed to eject but only the pilot survived, and was taken prisoner. According to Chinese statistics, between 1964 and 1971 PLAAF J-6s and J-7s (licence-built MiG-21F-13s) destroyed 21 Taiwanese and USAF aircraft, including two A-6s, two RF-101Cs, one F-104C, one Douglas A-3 Skywarrior and a number of Ryan BQM-34A Firebee reconnaissance drones. J-6s scored 15 of these 'kills', including seven over water.

An East German MiG-19S is prepared for a night flight. Although lacking radar, the MiG-19S could still provide a limited nocturnal capability when flown under strict GCI control in good weather.

During the Sino-Soviet border conflict, PLAAF J-6s often intruded 1-1.5 km (0.6-0.9 miles) into Soviet airspace. In January 1974 they flew air cover for the Chinese commandos trying to capture the Parasel'skiy islands on the Amur river.

Chinese defections

There were six cases of J-6 pilots defecting, five of them to Taiwan or South Korea. On the sixth occasion, on 25 August 1990, PLAAF pilot Wang Bo-yu defected to the USSR in his J-6, landing at Knevichi air base. Five days later the aircraft was returned and the pilot extradited to China. Trying to escape from the People's Republic of China was a dangerous task. On 27 May 1983, a J-6 attempting to defect was shot down into the Strait of Taiwan. Even if the defection were successful, the pilots could not be completely safe from the Chinese secret service sworn to find and execute the traitors. On 10 January 1966, a Taiwanese Grumman HU-16 Albatross was shot down into the sea by PLAAF fighters, killing all on board. The reason, according to Chinese intelligence reports, was that the amphibian carried delegates to an international convention, including three Chinese defectors.

In March 1979 J-6s periodically took part in the Chinese intervention in the northern provinces of Vietnam. However, the Chinese were up against a well-equipped Vietnamese air defence and lost at least one J-6 to ground fire. Still, incursions by PLAAF fighters into Vietnamese airspace continued long after Chinese ground troops had been withdrawn.

During the 'Prague Spring' of 1968 MiG-19s operated by Soviet and Polish crews were moved into Czechoslovakia to dissuade intervention from the West while the internal situation was rectified. Here pilots from both nations stand at a Czech base in front of a MiG-19PM.

In 1967 the USA stepped up bombardments of North Vietnam, forcing the North Vietnamese government to beef up the air defence force. In addition to buying MiG-21PFV fighters (a 'Vietnamised', i.e., tropicalised version of the MiG-21PF 'Fishbed-B') from the Soviet Union, North Vietnam negotiated the delivery of a number of J-6s from China. Forty-four were delivered in 1968-69, equipping the 925th Fighter Regiment.

This view of a MiG-19PM emphasises the sharply swept wing and tail surfaces. A characteristic feature of the 'Farmer' was the 'pen-nib' fairing between the two jetpipes.

The MiG-19PM was in Soviet service from 1958, joining other WarPac air arms a year later. In front-line service the aircraft's career lasted around a decade. This aircraft served with the LSK/LV's JFG 3 at Preschen.

The MiG-19's baptism of fire in the Vietnam War was in the spring of 1972 when the USA launched Operation Linebacker. The North Vietnamese pilots used the good climb rate and acceleration characteristics of the MiG-19 to the full, usually employing a 'hit-and-run' tactic initiated after the American pilots introduced the 'high-speed yo-yo'. The J-6s usually patrolled the approaches to the target at low altitude, with the more modern MiG-21s flying top cover. When the MiG-21s engaged the US aircraft and a dogfight began, the J-6 would pick a target, then zoom up unexpectedly, make one firing pass at the target and dive for cover immediately. This tactic required good marksmanship, but if you had that, it was fairly effective.

One of the great strengths of the MiG-19S was its cannon armament of three NR-30s. Compared to Western cannon such as the ADEN or DEFA, the NR-30 fired a much heavier projectile at much greater muzzle velocity. The weapon proved to be very useful in the attack role, especially when loaded with armour-piercing ammunition.

A good illustration of this tactic is the battle which took place over the Red River Valley on 10 May 1972. Four F-4Es of the elite 555th 'Triple Nickel' TFS/432nd TRW appeared on the scene to destroy any enemy fighters patrolling the area and to clear the way for a strike group heading for the Doumer bridge. Right over the bridge they were met head on by four MiG-21PFVs. Flight leader Major R. Lodge and his wingman Captain Merckle shot down two MiGs with Sidewinder missiles; the other two MiGs parted and turned left and right, and Lodge went after one of them.

"Suddenly a MiG-19 popped up from below," Lodge's RIO, Captain R. Loacher, recalled. "I had no time to even warn my pilot when I felt us taking hits in the fuselage from the MiG's [USAF pilots did not distinguish between the MiG-19S and J-6] 30-mm guns. The Phantom immediately started banking, out of control, as fire erupted behind the cockpit. The heat was so intense that the Plexiglass canopy immediately became opaque and started warping. I could see nothing, feeling that the aircraft was spinning towards the ground." Another MiG-21 and another F-4E were shot down in that fierce battle; the other Phantom was also destroyed by a J-6.

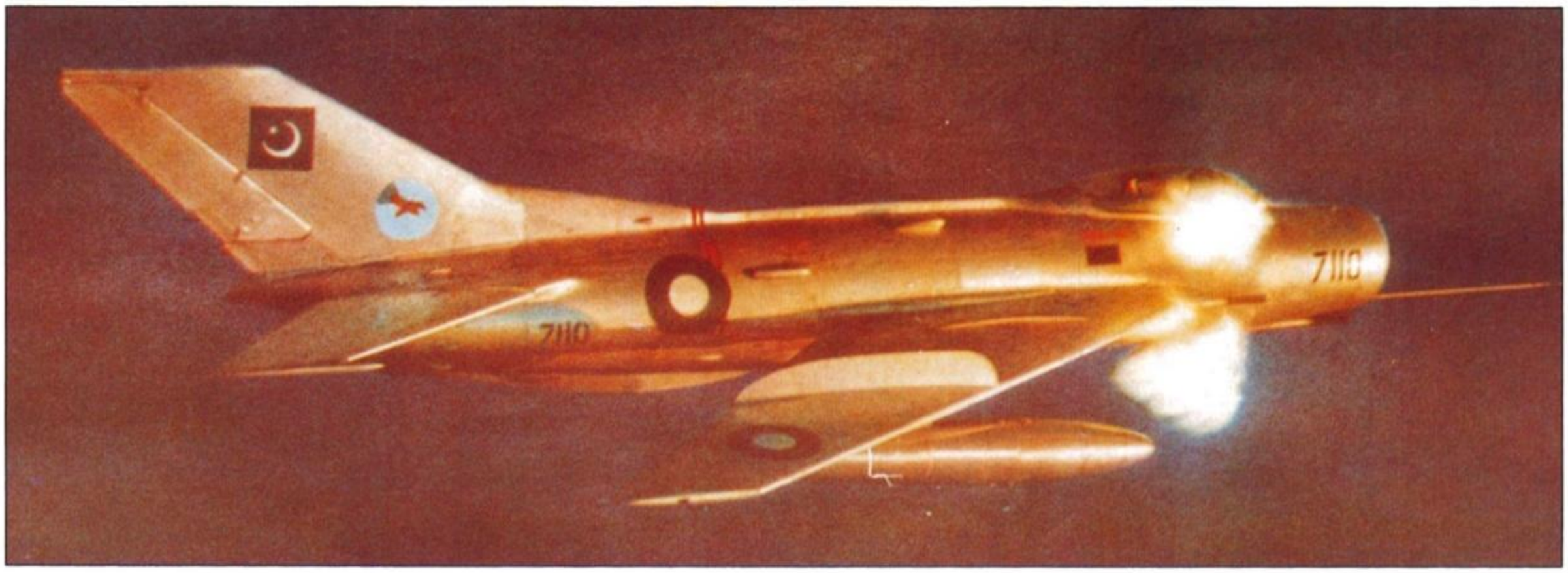
Another favourite Vietnamese tactic was to let out a natural metal MiG-19 over the jungle to act as bait for US fighters. Coming in to attack, they would be jumped by a camouflaged MiG-17F or MiG-21 flying at low altitude. USAF pilots regarded the MiG-19 as a potent adversary – a heavily armed fighter with better manoeuvrability than the MiG-21 and greater speed than the MiG-17F.

In 1977 China supplied 16 J-6s to its ally, Pol Pot's regime in Kampuchea. However, Pol Pot was too busy exterminating his own people to think about keeping up an air force. When Vietnamese forces crushed the Khmer Rouge troops and overran Phnom Penh three years later, they found only six aircraft in semi-assembled condition, with the others still waiting their turn in crates. The Vietnamese put them to good use, assembling them and pressing them into service against the remnants of the Khmer Rouge which had holed up in the jungle near the Thai border.

In 1979 Vietnamese J-6s were in action against the Khmer Rouge once again. Some sources state that the Vietnamese shot down three Kampuchean fighters (possibly flown by North Korean 'mercenary' pilots) with no losses for themselves.

Middle East

The first non-WarPac operators of the MiG-19S were Syria and Egypt, taking delivery of 40 and 100 aircraft, respectively, between 1958 and 1962. In the early 1960s the Egyptian air force was very active in North Yemen,



Mikoyan MiG-19PM Jagdfliegergeschwader 3 'Vladimir Komarov' LSK/LV, Preschen

Surprisingly few 'Farmers' were supplied to the Luftstreitkräfte und Luftverteidigung, all serving with JFG 3 at Preschen. Two batches were supplied in 1959, one of 12 MiG-19S day-fighters and one of 12 radar-equipped MiG-19PMs. Although they equipped two squadrons of JFG 3, it is believed that the two variants were shared by both component units. The type was retired from service in 1967.

JFG 3 'Vladimir Komarov'
What became JFG 3 was formed on 14 December 1954 with Yak-11 and Yak-18 trainers. In August 1956 the unit became 3. Fliegergeschwader, equipped with the MiG-15bis. MiG-17s followed in October 1957. In 1951 the unit began operations with two squadrons of MiG-19S/PMs, and on 1 November 1961 activated a third squadron to fly the MiG-17F. This third Staffel transitioned to the MiG-21F-13 in 1962, and in 1967/68 the remaining two squadrons gave up their MiG-19s in favour of later MiG-21 variants. One squadron was subsequently chosen to fly the MiG-29 'Fulcrum', and the Geschwader was still MiG-21/29-equipped at the time of reunification and absorption into the Luftwaffe. Commanding officers during the MiG-19 era were Major Ifland (1958-59), Major Gleis (1959-64) and Oberstleutnant Grosse (1964-68).

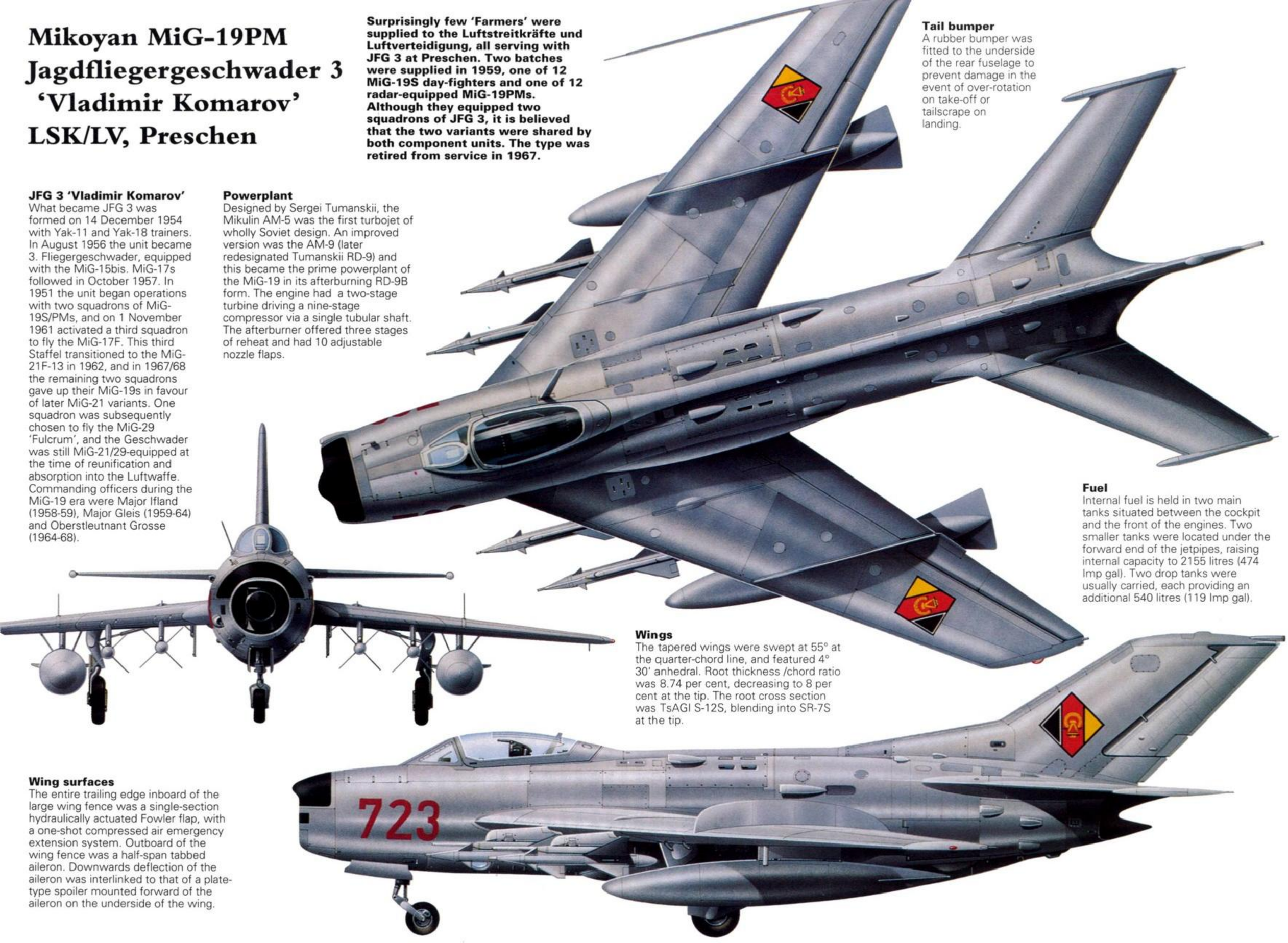
Powerplant
Designed by Sergei Tumanskii, the Mikulin AM-5 was the first turbojet of wholly Soviet design. An improved version was the AM-9 (later redesignated Tumanskii RD-9) and this became the prime powerplant of the MiG-19 in its afterburning RD-9B form. The engine had a two-stage turbine driving a nine-stage compressor via a single tubular shaft. The afterburner offered three stages of reheat and had 10 adjustable nozzle flaps.

Tail bumper
A rubber bumper was fitted to the underside of the rear fuselage to prevent damage in the event of over-rotation on take-off or tailscrape on landing.

Fuel
Internal fuel is held in two main tanks situated between the cockpit and the front of the engines. Two smaller tanks were located under the forward end of the jetpipes, raising internal capacity to 2155 litres (474 Imp gal). Two drop tanks were usually carried, each providing an additional 540 litres (119 Imp gal).

Wings
The tapered wings were swept at 55° at the quarter-chord line, and featured 4° 30' anhedral. Root thickness /chord ratio was 8.74 per cent, decreasing to 8 per cent at the tip. The root cross section was TsAGI S-12S, blending into SR-7S at the tip.

Wing surfaces
The entire trailing edge inboard of the large wing fence was a single-section hydraulically actuated Fowler flap, with a one-shot compressed air emergency extension system. Outboard of the wing fence was a half-span tabbed aileron. Downwards deflection of the aileron was interlinked to that of a plate-type spoiler mounted forward of the aileron on the underside of the wing.



Above: Cuba's small air force included several MiG-19s, and they were used in many operations against various US/CIA insurgency and intelligence-gathering operations. This is a MiG-19P, now on display in a Havana museum.

Above left: Soviet radar-equipped MiG-19Ps were modified to carry K-13 ('Atoll') infra-red guided missiles, retaining the wingroot cannon. This aircraft also carries ORO-57K rocket launchers on the inboard pylons.

Left: In the Middle East, Egypt was the principal MiG-19 protagonist, using the type in numerous battles with Israel. Shenyang F-6s (illustrated) supplanted the original Soviet-built aircraft, and a handful are still in service in the late 1990s.

supporting the Republicans in the Yemeni civil war. Not having an aerial adversary to fight, the Egyptian MiG-19s were tasked with ground attack, hitting, among other things, a number of targets in South Yemen – even though this was a British protectorate at the time.

The first air-to-air engagement by Egyptian MiG-19s was on 29 November 1966 when two MiGs were attacked by two Israeli Mirage IIICs. Both MiGs were destroyed, one of them with a MATRA R-530 AAM.

Some sources claim that in June 1967, five of the United Arab Republic air force's six MiG-19 squadrons were based in Egypt and one in Syria. According to other sources, about 60 UARAF MiG-19s were airworthy at the beginning of the Six Day War. Along with MiG-15bis and MiG-17F fighters, they equipped nine mixed fighter-bomber squadrons (four Egyptian and five Syrian).

More than 20 MiG-19Ss were destroyed on the ground by Israeli air strikes on the first day of the war, 5 June 1967; eight more were shot up while attempting to get airborne. IDF/AF sources state that Israeli Mirage IIICs shot down 29 MiG-19Ss with no losses for themselves. Yet Israeli pilots praised the MiG unanimously as 'an excellent dogfighting machine'.

Iraq bought 50 Soviet-built MiG-19Ss in 1960 but resold most of them later to Uganda, Afghanistan and North Korea. The fighters saw action against Kurdish rebels in 1974; the Kurds claimed one aircraft shot down in April. Iraqi MiG-19Ss were not used against Israeli forces.

Forty more MiG-19s – this time Chinese-built F-6s – were acquired via Egypt in 1983. Since the Iraqi air force had sufficient numbers of more modern interceptors, the F-6s were used as ground attack aircraft. However, it soon became apparent that helicopters were better suited for this role due to Iran's weak air defence. The F-6s were relegated to the training role, and none was airworthy by the time Operation Desert Storm began.

In the same year, the Islamic Iranian Air Force bought 24 F-6s from North Korea. They were flown by Guards of the Islamic Revolution, Khomeini's fighter pilot elite, and used to defend Tehran and other major cities, but no victories were claimed.

Indo-Pakistan War

The largest conflict in which the F-6 saw action was the Indo-Pakistan conflict which began in December 1971. By then, the F-6 formed the backbone of Pakistan's fighter force,

MiG-19PMs lasted in East German service long enough to receive tactical camouflage. The PM suffered from poor performance (compared to the MiG-19S) and unreliable radar.

The last European bastion of the MiG-19 is Albania, whose air force operates around 60 Shenyang F-6s on both fighter and ground-attack duties. The status of this force following the mid-1990s unrest in the Adriatic nation is unknown.

serving with Nos 15, 19 and 25 Squadrons. PAF F-6s were used both in the counter-air and ground attack roles.

At daybreak of 4 December more than 70 Indian Air Force Hawker Hunter FGA.Mk 9 and Sukhoi Su-7B 'Fitter-A' fighter-bombers made a massive strike against Pakistani airfields. However, the surprise element on which the Indians had counted did not work: the attacking force was met by PAF F-6s as it approached the targets. The first IAF aircraft to be shot down was a Hunter destroyed on 4 December by Lieutenant J. Quasi near the Mianwali air base. The same day Lieutenant K. Latif shot down a Su-7B and Lieutenant Shafraz damaged another. Meanwhile, F-6s flew strike missions against Indian ground troops, destroying an 18-gun artillery battery and an ammunition dump.

On 7 December Lieutenants Atig and Mushtaf attacked a group of four IAF Su-7Bs, shooting down two, while an F-6 flown by Lieutenant Vayad Ali was shot down by AA artillery. Another F-6 flown by Lieutenant Shaheed Reza was lost to Indian AA guns on 11 December. According to Pakistani sources, during the conflict the F-6s destroyed one MiG-21 (model unknown), six Su-7Bs and two or three Hunters, and damaged four more IAF aircraft. Wing Commander Lieutenant Colonel S. Khatmi was the most successful, scoring three 'kills' (he had a total of five to his credit, with two more IAF aircraft downed in 1965).

The addition to Pakistani F-6s of AIM-9P Sidewinder missiles and Western avionics significantly enhanced their capability, while Martin-Baker seats improved the chances of a pilot's survival enormously. This No. 15 Sqn ('Cobras') aircraft is from an early batch, with the original brake chute. On later Shenyang aircraft, it was moved to the base of the fin.

On the minus side, Pakistan acknowledged the loss of four F-6s – one shot down in a dogfight and three by AA artillery, including one by friendly fire. India claimed four F-6s shot down by fighters and four more destroyed on the ground, denying at the same time the loss of any Su-7Bs to Pakistani F-6s.

The PAF was pleased with the F-6's combat debut and bought another large batch soon afterwards, increasing the F-6 force to around 130. In November 1980 an overhaul plant built with Chinese assistance was opened in Kamra to handle repair and upgrade work on the F-6. The upgrades included the installation of Martin-Baker ejection seats and pylons for Sidewinder missiles; PAF F-6s flew with non-standard drop tanks (so-called Misawa tanks borrowed from the Lockheed P-80 Shooting Star).

Starting in 1979, PAF F-6s guarded the Pakistani-Afghan border from Afghan air force and Soviet air force aircraft after the Soviet Union deployed troops in Afghanistan. Initially, activity was limited to driving off intruders but it evolved into real aerial battles later. Remarkably, the type stayed in service even after the introduction of the General Dynamics F-16A and the CATIC F-7P Airguard (a Chinese spin-off of the MiG-21F-13) and still soldiers on in the airfield defence role on all major PAF bases.

Africa

The F-6 was delivered mainly to states which were in a perpetual state of civil war or border conflicts with neighbouring states. Tanzania used the type operationally during the 1978-79 war with Uganda. Sudanese F-6s supported the government's operations against separatists in southern Sudan, during which operations at least one was shot down. Somali F-6s flown by local and mercenary pilots patrolled the Sudanese and Ethiopian borders; two were lost near Hargeis during operations against the rebel Somalian National Movement in 1988. Only three remained airworthy at the end of the year due to the lack of spares, and the entire air force was derelict and the airfields destroyed by the time US troops were sent to Somalia in December 1992.

Yefim Gordon; original translation by Dmitri Komissarov
Additional material by David Donald

MiG-19 Variants

SM-1 (I-340)

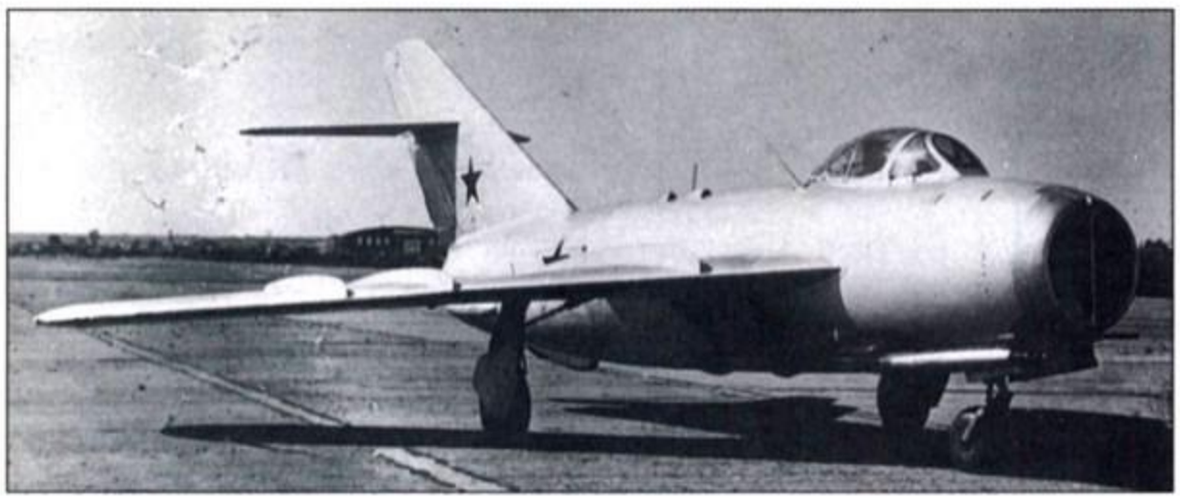
At a Kremlin meeting on 30 July 1950, Joseph V. Stalin brought up the issue of a new fighter with a bigger combat radius than the MiG-15 'Fagot' and the MiG-17 'Fresco'. The twin-engined aircraft was envisaged in two basic versions: an all-weather interceptor equipped with powerful radar, and a highly manoeuvrable supersonic tactical fighter having a high rate of climb and a range not less than 2000 km (1,242 miles). When used as an escort fighter, it was to fly on one engine to save fuel and start up the other engine for a dogfight, but this rather questionable concept was short-lived.

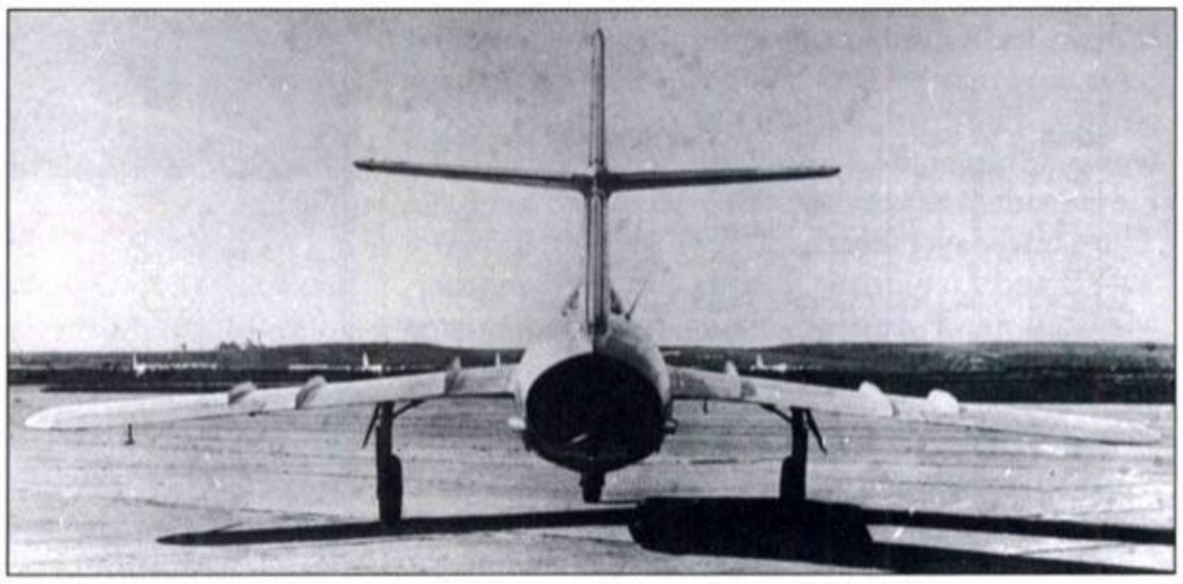
New, powerful, fuel-efficient engines were needed – clearly, they had to be axial-flow turbojets because centrifugal-flow turbojets were too thirsty and too bulky to fit two of them into a fighter. The Mikoyan Design Bureau (coded OKB-155 for security reasons) chose the Mikulin AM-5 rated at 49.03 kN (4,409 lb st) which was by then at an advanced development stage. To verify the new powerplant, a MiG-17F was converted in 1951 into the I-340 experimental fighter (I = *istrebeetel* – fighter), designated SM-1 by Mikoyan, which was effectively a testbed for the AM-5. It had a new aft fuselage with the two engines mounted side by side. The compact engines allowed three additional fuel cells totalling 770 litres (170 Imp gal) to be installed in the fuselage.

The aircraft made its first flight at the end of the year; Mikoyan test pilots Konstantin K. Kokkinaki and Georgi A. Sedov performed the test programme, with A. V. Minayev as project engineer. Top speed at 7000 m (22,965 ft) was 1193 km/h (741 mph), and rate of climb was 40.6 m (133 ft) per second. The original AM-5s were later replaced by AM-5As uprated to 21.08 kN (4,740 lb st), but the planned AM-5F engines with afterburners (F = *forseerovannyy* – uprated or, in this case, afterburning) were never installed. The SM-1 contributed immensely to the future success of the MiG-19, as the definitive fighter was known, but putting it into production was never considered. The AM-5 had its share of troubles, such as turbine blades breaking.

Concurrently, the design bureau led by Arkhip M. Lyul'ka developed the powerful TR-3A axial-flow turbojet. However, the single-engined I-350 experimental fighter suffered an engine failure in its first flight. (The aircraft was also known as *izdeliye* 'M', *'izdeliye'* – meaning 'product' – being a term often used for coding items of military hardware). The tendency of the TR-3A to flame out could not be rectified and the I-350 programme was terminated after only five flights.

The installation of twin engines necessitated a fattening of the rear fuselage to accommodate them.



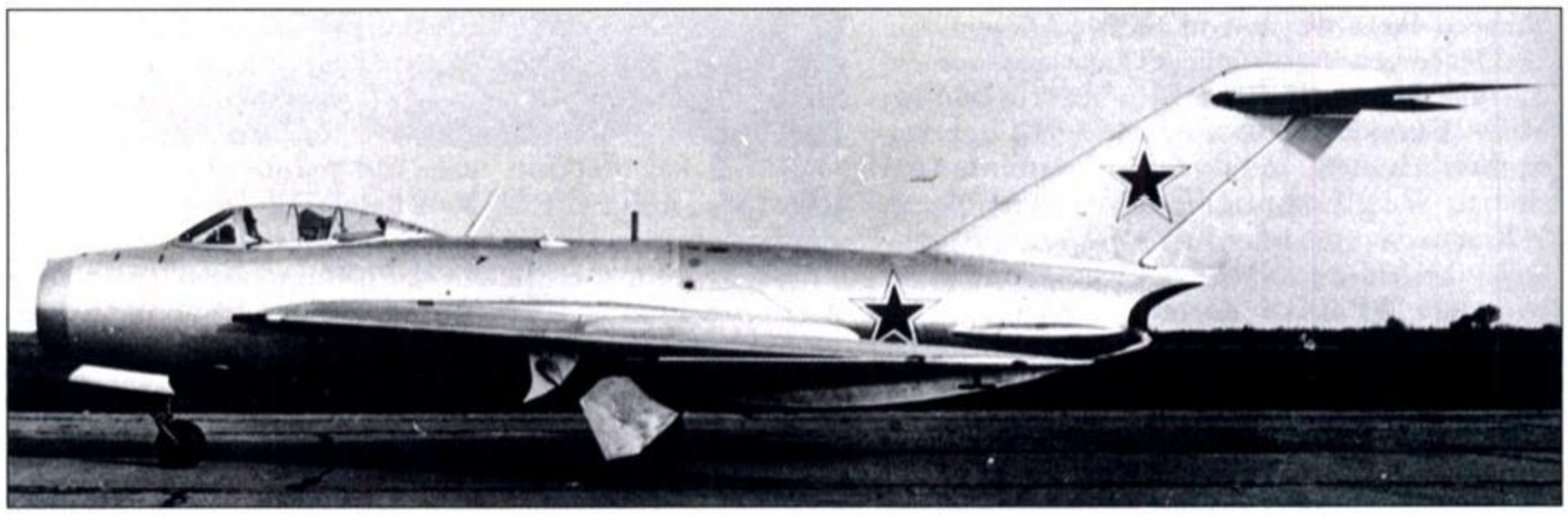


The SM-1 utilised a MiG-17F airframe, and retained the nose armament. The initial Mikulin AM-5 engines were subsequently replaced by AM-5As.

SM-2 (I-360)

Building on experience with the SM-1, Mikoyan developed the I-360 escort fighter (a.k.a. SM-2) built around two AM-5As. The aircraft was designed pursuant to a decree of the USSR Council of Ministers dated 10 August 1951; however, project studies began in June and were completed in December, with Deputy General Designer A. G. Broonov as project chief. A. A. Choomachenko was responsible for the SM-2's aerodynamics, Rostislav A. Belyakov for the control system, Gleb Ye. Lozino-Lozinskiy for the powerplant, and D. N. Kurgoozov was the structural engineer.

Although the SM-1 was, in effect, a heavily modified MiG-17F, the SM-2 was a new design – even though it owed much to earlier Mikoyan fighters. It was a twin-engined mid-wing fighter. The thin wings developed by the Central Aero- and Hydrodynamics Institute (TsAGI) were optimised for supersonic flight and were the main novel feature. They were swept back 55° at quarter-chord, had 4°30' anhedral, reduced span compared to the MiG-17, and one boundary layer fence on each side. The high-speed airfoil had a thickness-to-chord ratio of 8.73 per cent at the roots and 8 per cent at the tips.



The fuselage was extended by 1.6 m (5 ft 3 in). Unusually, the SM-2 had a T-tail, with the fin swept back 56° and the stabilisers 55° at quarter-chord. The one-piece sliding bubble canopy was slightly longer than that on previous fighters and the ejection seat featured a visor protecting the pilot's face.

The armament was also different. As early as the MiG-9 'Fargo', it had been noted that nose-mounted guns caused the engines to surge when gun blast gases were ingested. This was not too critical on the MiG-15 and MiG-17 because centrifugal-flow turbojets are less sensitive to turbulence generated by gun blast gases. On the SM-2, however, the problem reappeared, so weapons engineer N. I. Volkov suggested installing the guns (two 37-mm Nudelman N-37Ds with 100 rpg) in the wingroots.

Two SM-2 prototypes and a static test airframe were built. The first prototype, SM-2/1, was transferred to the Flight Research Institute (LII) at Zhukhovskii on 26 April 1952, and began taxiing trials on 9 May. On 24 May G. A. Sedov made the first flight; main performance data were obtained but the test programme was suspended on 28 September after 46 flights because of powerplant problems. On 30 September the SM-2/1 was returned to the Mikoyan experimental plant for modifications, returning to LII with new engines on 14 November.

Eight more flights were made between 23 and 28 December, in which the aircraft logged a total of 40 hours 30 minutes. The SM-2/1 reached Mach 1.16 in a shallow dive and Mach 1.045 in level flight at 10000-11000 m (32,808-36,089 ft); maximum IAS was 1200 km/h (745 mph). The aircraft was performing better than anticipated, attaining a maximum TAS of 1225 km/h (760 mph) at 3000 m (9,842 ft) and 1180 km/h (733 mph) at 7000 m (22,965 ft); the project called for these speeds to be reached at 5000 m (16,404 ft) and 10000 m (32,808 ft), respectively. It climbed to 10000 m in 2.7 minutes rather than the required three minutes, and had a service ceiling of 16400 m (53,805 ft) – 400 m (1,312 ft) more than planned. On the other hand, range was 2005 km (1,245 miles) in clean condition and 3300 km (2,049 miles) with drop tanks, which was 95 km (59 miles) and 300 km (186 miles), respectively, shorter than anticipated.

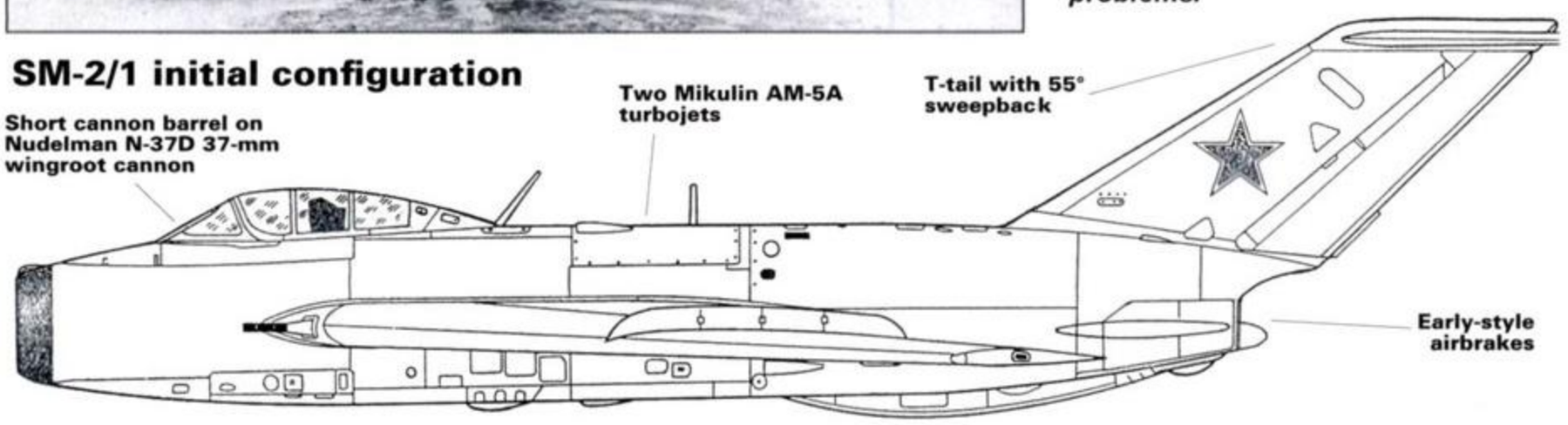
Gun firing trials were conducted both on the ground and in the air. Despite the wing installation of the guns, gun blast gases disrupted engine operation, but the engines could be restarted easily at up to 7000 m (22,965 ft). Field performance was very similar to contemporary jet fighters and the brake parachute was found satisfactory.

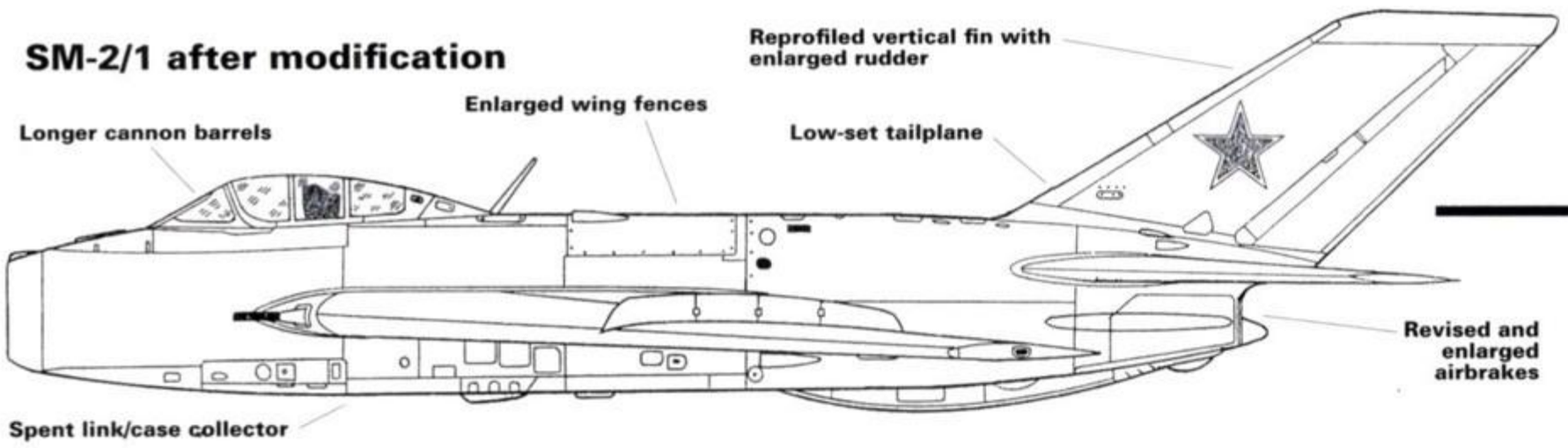
In addition to performance testing, the

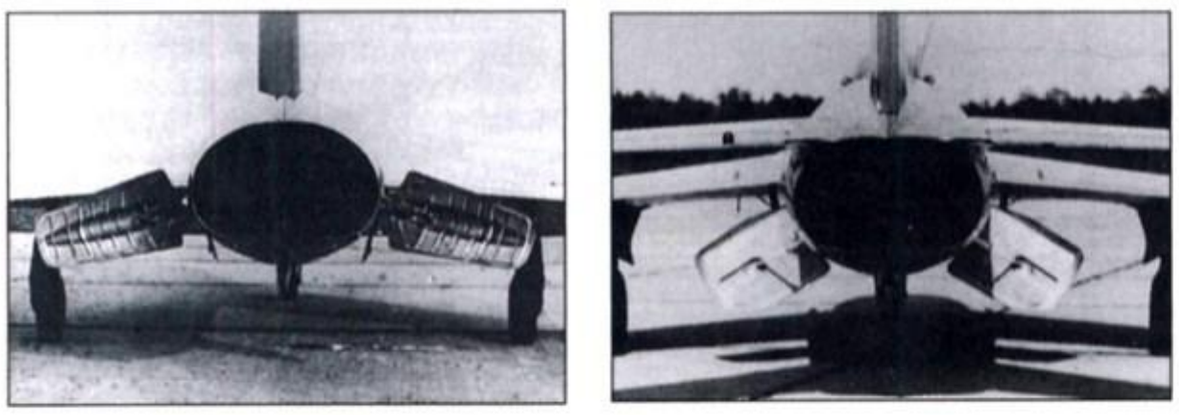
The SM-2/1 was an important interim step towards the MiG-19 production aircraft. It featured a T-tail at first.

This is the second SM-2, which was completed to the original T-tail configuration but featured longer blast muzzles on the wingroot cannon to ease gas ingestion problems.

SM-2/1 initial configuration


Short cannon barrel on Nudelman N-37D 37-mm wingroot cannon
Two Mikulin AM-5A turbojets
T-tail with 55° sweepback
Early-style airbrakes





These two photos show the SM-2/1 before (left) and after (right) modification, detailing the major changes made to the airbrakes.

SM-2/1 flew a simulated escort mission with the prototype Tu-16 (Tu-88) 'Badger-A', flying at 900-950 km/h (559-590 mph) and 10000-11000 m, some 1500 m (4,921 ft) behind and 1000 m (3,280 ft) above the bomber. The mission included mock combat with an 'aggressor' MiG-17 attacking from behind.

Pilots reported that the SM-2's stability and manoeuvrability was better than on the MiG-15 and MiG-17. Still, pitch and roll control at extreme speeds was found to be inadequate; the suggested remedy was to install slab stabilisers (stabilators) for pitch control and spoilers to assist the ailerons in roll control. Other deficiencies included a higher unstick speed and a higher approach speed than on the MiG-17.

The second prototype, SM-2/2, was completed in 1952 and differed in having guns fitted with long muzzle brakes to cope with the blast gas ingestion problem, gun blast plates at the wing-roots to protect the fuselage skin, and slightly larger airbrakes. The aircraft was delivered to LII on 12 September and made its first flight on 28 September with Sedov at the controls. When the factory tests were completed exactly four months later, the aircraft had made 15 flights and logged 14 hours 20 minutes; the test programme included mainly engine, airbrake and armament testing.

On 25 February 1953 the SM-2/2 began state acceptance trials at NII VVS (Air Force Research Institute). The aircraft was mostly flown by test pilot V. G. Ivanov (though pilots V. S. Kotlov and A. P. Sooproon also participated in the trials), and V. V. Mel'nikov was project engineer. The programme was suspended on 6 March when the aircraft was found to suffer from instability at high angles of attack, entering a deep stall and a spin (from which it fortunately recovered).

Aileron efficiency was poor because of the thicker boundary layer on the outer wings, indicating that the wing fences were not tall enough. Tailplane buffet was also experienced at certain speed/AoA combinations, and defects in the fuel system were discovered. All things considered, the aircraft was returned to the experimental shop for modifications.

After additional wind tunnel tests the SM-2/1 was fitted with a conventional tail unit, with appropriate modifications to the rear fuselage structure, and tailplane area was increased from 3.47 m² (37.31 sq ft) to 5.5 m² (59.13 sq ft). The fin root and tip were modified and rudder area was increased. To avoid tailplane buffet, the airbrakes were moved forward and down and enlarged to 1.07 m² (11.5 sq ft); airbrake deflection was 50°.

Irreversible hydraulic actuators were fitted to the elevators and ailerons, replacing the earlier reversible actuators. New muzzle brakes were fitted. A spent case and link collector was added in the lower forward fuselage to prevent empty cases from damaging the airbrakes and tail unit when the guns were fired. It caused the capacity of the forward fuel cell to be decreased by 100 litres (22 Imp gal).

The avionics suite included an RSIU-3 UHF communications radio, an ARK-5 ADF, an ASP-4N gunsight linked to a Radal'-M (= radiodal'nomer – radio rangefinder) gun ranging radar, an RV-2 radio altimeter and an Oozel (knot) IFF transponder. The modifications increased empty weight by 150 kg (330 lb).

Before the conversion of the SM-2/1, the second aircraft was used in a test programme from 13 March to 10 April 1953 intended to discover the reason for the high Alpha/poor stability problem. The programme comprised eight flights at 12000 m (39,370 ft) with different wing fence and flap positions. These experiments turned out to be futile, as the aircraft was still extremely unstable and prone to spinning at high Alpha, so finally the SM-2/2 was converted to the same standard as the first prototype.

The two aircraft re-entered flight test on 9 May; the factory test programme lasted until 25 June for the first prototype and 21 June for the second. The main objective was to determine high-Alpha behaviour with the new tail unit. Tests showed that true airspeed had decreased by 10-15 km/h (6-9 mph) at any altitude; range was 1925 km (1,195 miles) in clean condition and 3228 km (2,004 miles) with drop tanks. Maximum *g* loads attained were +8*g* for the SM-2/1 and +9.56*g* for the SM-2/2. Ceiling and rate of climb were not measured.

The new muzzle brakes had the desired effect, in that firing the guns no longer affected engine operation. The test report by G. A. Sedov said that the modifications had eliminated the shortcomings noted earlier; spin recovery was safe and reliable, and the first prototype was cleared for state acceptance trials. Nevertheless, the height of the wing fences was increased almost three times at this stage.

The factory tests did not proceed altogether without incident. On one occasion, one engine of the SM-2/1 stopped responding to throttle movements at 500 m (1,640 ft), followed soon after by the other engine. With quite a large fuel load still remaining, Sedov managed to make a U-turn and land well down the runway; the aircraft overshot, crashing through the perimeter fence but miraculously remaining almost undamaged. Sedov made a total of 132 test flights on both prototypes during 1952-53.

The SM-2/1 (right) and SM-2/2 (below) display the low-set tailplane modification. Both still have the shallow wing fences, later replaced by deeper units.

The state acceptance trials were resumed on 18 July 1953, with Lieutenant Colonel V. G. Ivanov and Lieutenant Colonel A. P. Sooproon as project pilots. Surprisingly, the result was very different from that obtained during factory tests. NII VVS pilots reported that the high-Alpha stability problem persisted and that active manoeuvring was unsafe at altitudes below 9000-10000 m (29,527-32,808 ft). The pitch instability could spoil the pilot's chances of aiming accurately during a dogfight.

Air force pilots were also critical of the SM-2's control system. The circuits were duplicated in case of failure and the elevator controls featured the world's first electric automatic flight control governor adjusting elevator deflection depending on airspeed. Originally the stick had an artificial-feel mechanism with two springs (both were used when the landing gear was down and only one when the gear was retracted); the second spring was activated automatically by gear extension. After Stage I of the state acceptance trials, the reversible aileron and elevator actuators were replaced by irreversible ones, and spoilers mechanically linked with the ailerons were added on the wing undersurfaces.

Still, pitch control obviously had to be improved even more. The state commission listed the aircraft's main shortcomings as follows: poor manoeuvrability and acceleration at high altitude, insufficient service ceiling (13600 m/44,619 ft) which restricted the SM-2's ability to escort Tu-16s, poor operation of the gun ranging radar and gunsight, poor field performance, no protective grids in the intake ducts preventing foreign object damage, and complicated servicing (mission preparations took 60 or 65 minutes, twice as long as for the MiG-17).

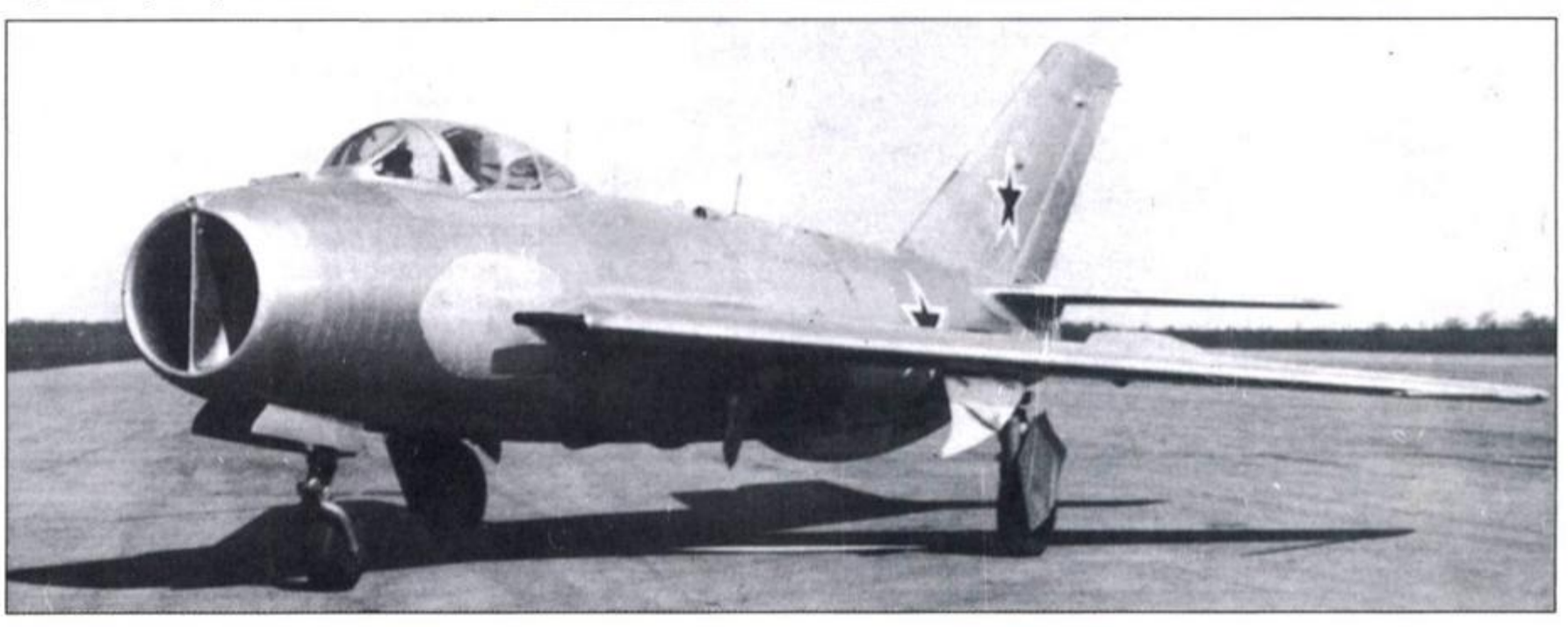
On the plus side, the SM-2 had better speed, range, rate of climb and endurance than both the basic MiG-17 and the MiG-17F, although it was inferior to both types in turn radius and time, take-off and landing run, and approach speed. The SM-2 was deemed suitable for escorting Il-28 'Beagle' and Tu-16 bombers to targets within a combat radius of 650-1000 km (403-621 miles), depending on when the drop tanks were dropped.

NII VVS pilots noted that the cockpit was roomier than the MiG-17's but that the wide canopy frames restricted forward visibility. Ground handling was satisfactory, if a little more phlegmatic than the MiG-17. No perceptible deterioration of stability was experienced at transonic speeds. Acceleration was rather lazy: the SM-2/1 went from 380 km/h (236 mph) to 450 km/h (279 mph) in 2 minutes 18 seconds, while the MiG-17F did the same in 1 minutes 22 seconds.

The state acceptance trials programme of the SM-2/1 at the Chkalovskii test centre east of Moscow and the Vladimirovka test centre in Akhtubinsk (near Astrakhan on the Volga River) was completed on 15 December 1953, by which time the aircraft had logged 103 hours 17 minutes in 128 flights. Considering the new aerodynamic layout of the aircraft and the potential to improve performance by fitting more powerful engines, the state commission recommended the SM-2 for service as an escort fighter, but only after all its deficiencies were rectified.

The military leaders believed in the SM-2 so strongly that flight manuals were circulated to air force units. However, the Mikoyan OKB was not about to put the aircraft into production as it was. Broonov and Belyakov were working on irreversible actuators for slab stabilisers when the SM-2 was still at the design stage. To eliminate the deficiencies found during the state acceptance trials, the Mikoyan OKB finally decided on a thorough redesign of the aircraft to feature a new powerplant, new armament and avionics.

The new aircraft would have a fuselage cross-section optimised to cut drag, redesigned wings and tail unit with increased leading-edge sweep (also to reduce drag), a new pilot escape system, and redesigned inlet ducts ensuring stable operation of the engines in all flight modes. The SM-2 was thus a stepping stone on the way to combat-capable supersonic fighters.



SM-9

The air force's demands to correct the SM-2's deficiencies, and the insufficient thrust of the AM-5 turbojets, led the Mikoyan OKB to develop a new fighter based on the SM-2. In 1953 the Mikulin engine design bureau produced the AM-9F afterburning turbojet rated at 25.5 kN (5,731 lb st) dry and 31.87 kN (7,164 lb st) in reheat. The new engine had identical dimensions to the AM-5, enabling Mikoyan to hasten work on the new aircraft.

The idea of evolving the SM-2 into a more capable fighter won government support. On 15 August 1953, when the SM-2's state acceptance trials were still in progress, the Council of Ministers issued a decree ordering the Mikoyan OKB to design and build a new tactical aircraft in two versions (tactical fighter and interceptor); this was followed 11 days later by a Ministry of Aircraft Industry (MAP) order to the same effect. The tactical fighter was to have two versions powered, respectively, by two axial-flow Mikulin AM-9F engines and one centrifugal-flow Klimov VK-7 engine; the twin-engined version was to be ready for state acceptance trials in April 1954.

The Mikulin-powered version bore the manufacturer's designation SM-9, but the fact that the service designation MiG-19 had by then been allocated to this 'paper aircraft' says much for the confidence the government had in the new aircraft. Once again, project studies began ahead of government directives and progressed in parallel with the single-engined version; N. Z. Matyuk was the SM-9 project chief. The two aircraft had much in common with the SM-2.

The first prototype, SM-9/1, was completed in late 1953 and rolled out on 21 December. The main external difference from the SM-2 was the recontoured and enlarged vertical tail. The cockpit was pressurised by engine bleed air and had armour protection – a 10-mm (0.39-in) steel plate at the front, a 16-mm (0.62-in) rear plate, a 25-mm (1-in) armoured headrest and a 64-mm (2.5-in) bullet-proof glass panel. It was equipped with an oxygen system comprised six spherical 2-litre (0.44-Imp gal) bottles.

The rear fuselage was widened to accommodate the afterburners of the AM-9B engines (this was the designation of the AM-9F's production version), and the nozzles were fitted with ejectors. The wings were identical to those of the SM-2, with 55° sweep at quarter-chord, but featured taller boundary layer fences (one on each side). The stabilisers swept back 55° at quarter-chord were fixed, with separate elevators. The aft fuselage housed a brake parachute with an area of 15 m² (161 sq ft) stowed in a ventral bay, and incorporated two lateral airbrakes.

The intake splitter dividing the intake duct into two channels routed around the cockpit had a concave leading edge like that in the MiG-17. All fuel was carried in the fuselage in two bag tanks (nos 1 and 2) and two integral tanks (nos 3 and 4); total internal fuel capacity was 2086 litres (459 Imp gal). Additionally, two 760-litre (167-Imp gal) drop tanks could be carried.

The armament consisted of three 23-mm (0.90-in) Nudelman-Richter NR-23 guns – two in the wingroots with 120 rpg and one low on the starboard side of the forward fuselage with 100 rounds. The fuselage skin was protected by blast plates. For ground attack sorties, two rocket pods with 57-mm (2.24-in) ARS-57 folding-fin aircraft rockets (FFARs) for ground attack (ARS = *aviatseeonnyy raketnyy snaryad* – aircraft rocket) could be carried under the wings.

A common hydraulic system powered the landing gear, flaps, airbrakes, adjustable engine nozzles, elevators and ailerons; the latter two were powered by BU-14 and BU-13 irreversible actuators, respectively. Avionics and equipment included an RSIU-3M Klyon (Maple) UHF radio ensuring communications within 350 km (217 miles) at an altitude of 10000 m (32,808 ft), an SRZO-1 Oozel-1 IFF transponder, an ARK-5 ADF, an OSP-48 blind landing system (including an MRP-48P marker beacon receiver), an ASP-5N computing gunsight linked to an SRD-1 Radal'-M gun ranging radar, two GSR-ST-6000A starter-generators and a 12SAM-55 battery (12 cells, 55 A/h).

The SM-9 had three pitot tubes – two at the wingtips and one under the nose on the fuselage centreline. The centre pitot could be tilted up on the ground to prevent damage by ground vehicles. All three wheels were fitted with brakes (KT-38A nosewheel, 550x180 mm and KT-37 mainwheels, 660x200 mm).

Taxiing trials began on 25 January 1954, and on 5 February the SM-9/1 took off with G. A. Sedov at the controls. Except for the fact that the afterburners would not light, the first flight went smoothly. Sedov reported that the aircraft handled well and could go supersonic. And so it did, cracking the sound barrier on the second flight with the afterburners working as they should. In another flight, another test pilot reached Mach 1.33 in level flight and Mach 1.44 in a shallow dive from 10600 m (34,776 ft), thus setting an unofficial world speed record.

Sedov made a total of 132 test flights on the SM-9/1. V. A. Arkhipov was project engineer and two engineers were attached from the Mikulin OKB to monitor the engines. The test report said that the "MiG-19 with two AM-9Bs-is 300-375 km/h (186-232 mph) faster than production tactical fighters."

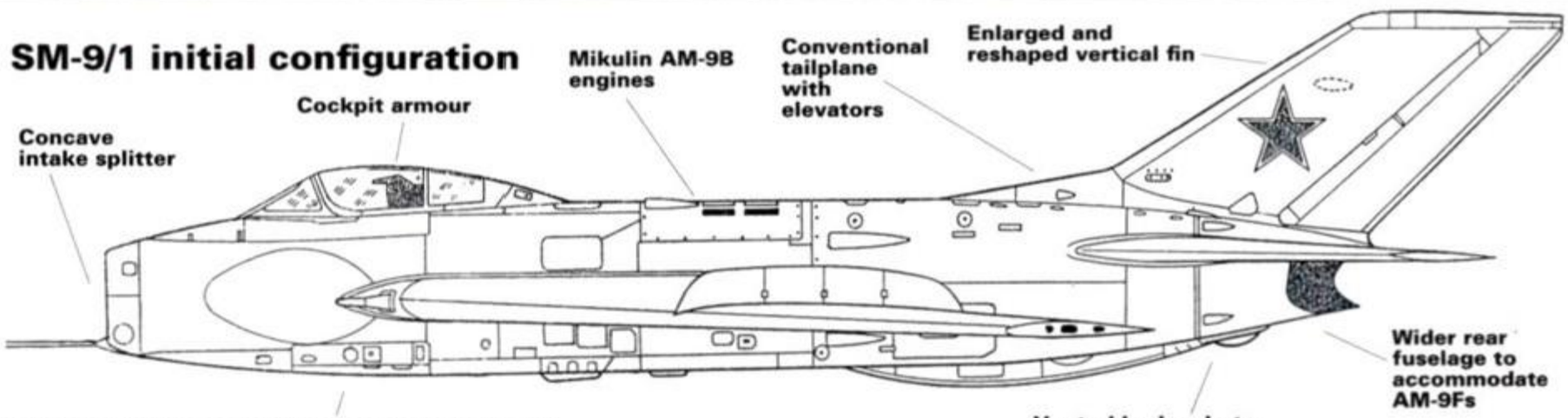
During spinning trials it was discovered that the engines tended to flame out because of airflow disruption when the aircraft entered a spin. To correct this, the intake splitter was modified on 10/11 August 1954, with a straight leading edge as on the SM-2; this also reduced the probability of surge due to gun blast gas ingestion when the fuselage-mounted gun was fired. The first flight with the revised intake (the prototype's 71st flight) was made on 12 August.

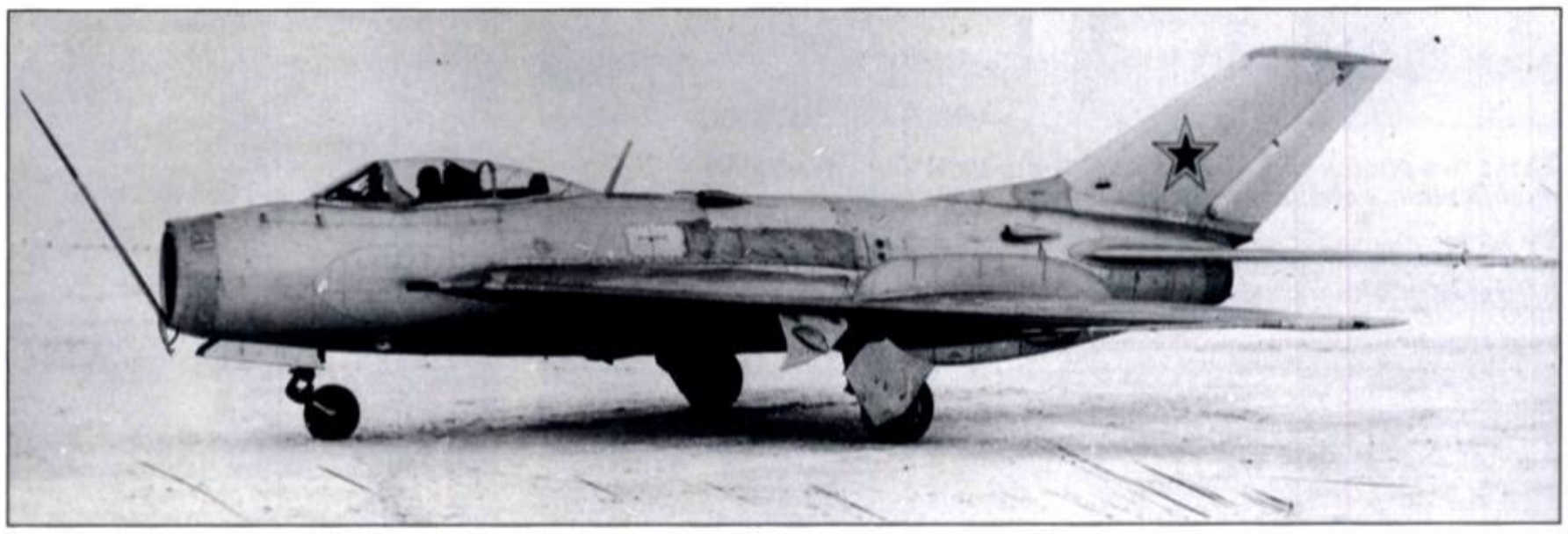
The SM-9/1 was stable throughout its speed and altitude envelope and CG range at all permissible angles of attack. Despite the higher gross weight, the aircraft had better field performance than the SM-2 because of the greater flap deflection angle. Roll stability was the same as on the SM-2, and pitch stability was much better. Aileron efficiency was increased by using new actuators. Sedov noted that elevator efficiency dropped at supersonic speed but remained acceptable, as were stick forces. Maximum speed during spin entry was 220 km/h (136 mph) and the aircraft recovered from the spin 0.5 to 0.75 turns after recovery was initiated.

The engines could be started in flight at up to 8000-8500 m (26,246-27,887 ft) and operated well at up to 16000 m (52,493 ft). The afterburners could be lit at up to 14,000 m (45,931 ft) but were unstable and tended to flame out above 16,500 m (54,133 ft), which this limited the prototype's range and rate of climb.

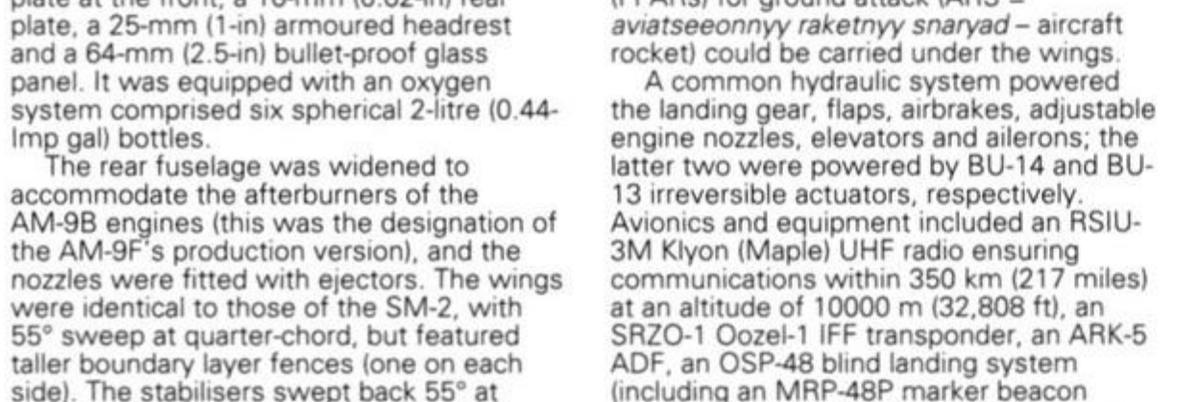
On 30 August 1954, the SM-9/1 was transferred to NII VVS for state acceptance trials which lasted from 3 September through 1 March 1955. In this time, the aircraft logged 105 hours 2 minutes in 166 flights, including 135 test flights, 25 verification flights and six ferry and training flights. Other pilots who flew the SM-9/1 included Lieutenant General Blagoveschchenskiy (the head of NII VVS),

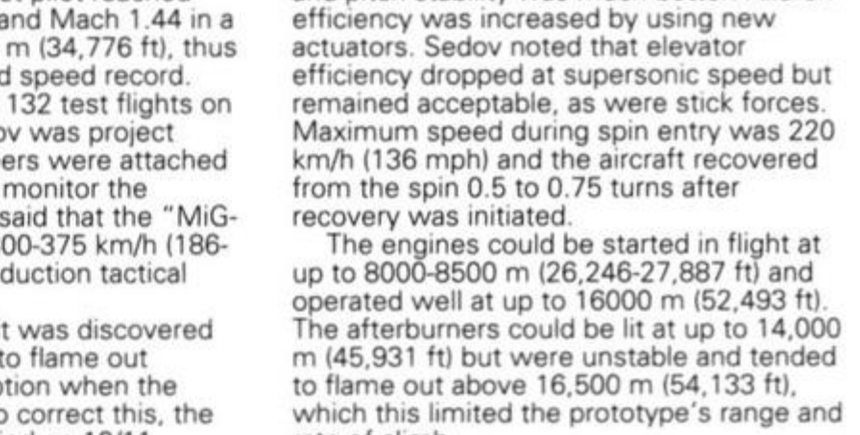
SM-9/1 initial configuration


Concave intake splitter
Cockpit armour
Mikulin AM-9B engines
Conventional tailplane with elevators
Enlarged and reshaped vertical fin
Wider rear fuselage to accommodate AM-9Fs
Nudelman-Richter NR-23 cannon with blast plate
Ventral brake chute

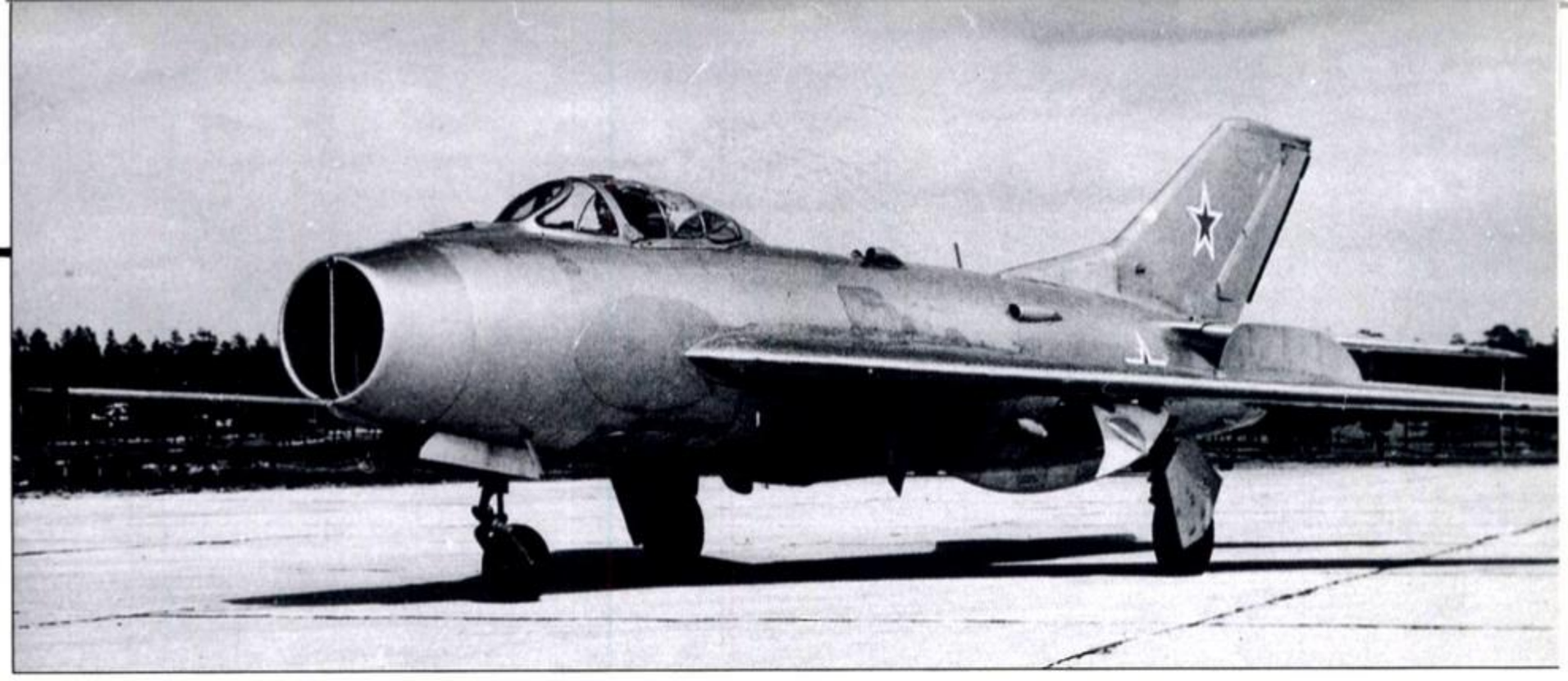


The SM-9/1 is seen in its first configuration. The aircraft had already been assigned the service designation MiG-19.



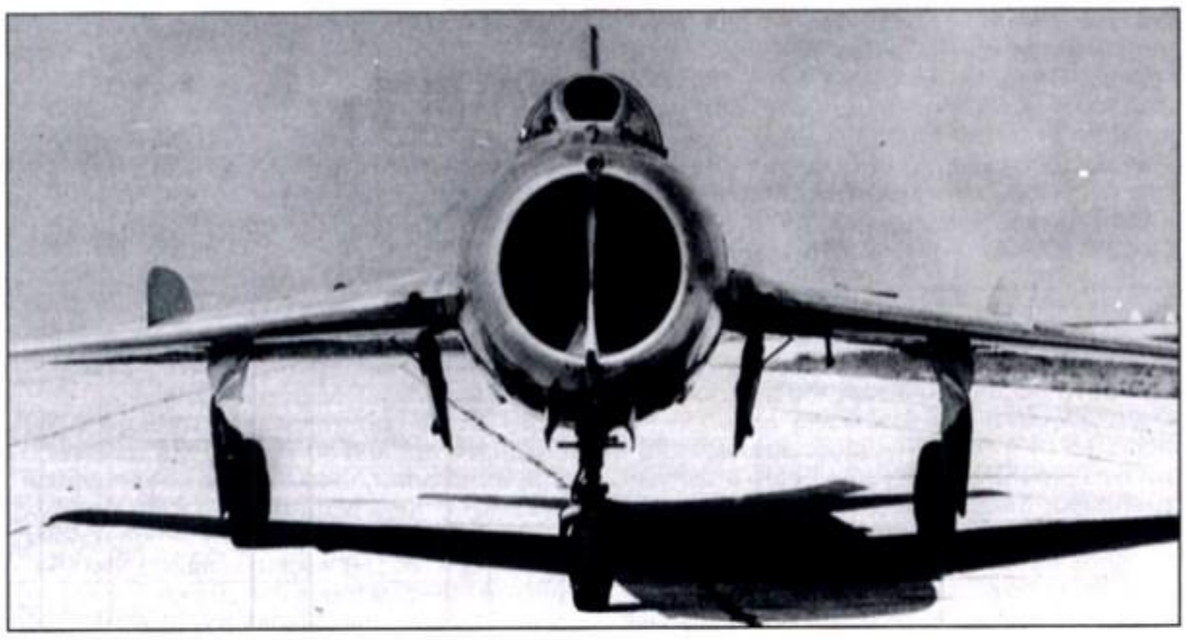


These two views show the SM-9/1 after it had undergone a series of improvements, including the fitment of a straight splitter plate. The aircraft flew a great deal, including the state acceptance trials in 1954/55. Of note are the three long pitot tubes (of which the nose tube hinged upwards for safe towing) and the large wing fences inherited from the later SM-2 configuration.



Right: The SM-9/2 addressed many of the problems of the first aircraft, notably the pitch control problem at supersonic speeds. The nose was also extended and a third airbrake was fitted.

Below: The SM-9/1 displays the MiG-17-style concave splitter plate with which it was originally fitted. This was subsequently altered to a straight profile surface which improved airflow during spinning, preventing engine flame-out.



Colonel Yuri A. Antipov, and Lieutenant Colonels Molotkov, V. S. Kotlov and Georgi T. Beregovoy, plus others. Eight were NII VVS pilots, two represented test centre no. 4, and the rest were service pilots from fighter units.

The act of acceptance signed on 21 March by Air Marshal Zhigarev stated that "at 10000 m (32,808 ft) the MiG-19 has a top speed 380 km/h (236 mph) higher than the MiG-17F and a service ceiling 900 m (2,952 ft) higher." The MiG-19 was the first Soviet fighter to reach a top speed of 1452 km/h (902 mph) and a service ceiling of 17900 m (58,727 ft), and to climb to 10000 m and 15000 m (49,212 ft) in 1.8 minutes and 3.7 minutes, respectively.

Deficiencies noted by the 12 pilots who flew the MiG-19 during state acceptance trials included unreliable operation of the afterburners at high altitude, poor operation of the gunsight, and poor manoeuvrability above 10000 m (32,808 ft) and at speeds higher than 1100 km/h (683 mph). The oxygen system could not support life if the cockpit decompressed (e.g., if hit by enemy fire), the three 23-mm guns clearly were insufficient and the advertised unguided rockets were not tested at all. (Nor were spinning and canopy jettisoning trials, or flights with drop tanks.) A request was voiced that the Minister of Aircraft Industry order the Mikoyan OKB to correct these deficiencies not later than the end of June 1955.

The afterburning RD-9Bs improved acceleration and rate of climb. Engaging the afterburners at 700 km/h (434 mph) and 1400 km/h (869 mph) increased thrust by 9.81 kN (2,204 lb st) and 18.34 kN (4,122 lb st), respectively, giving the MiG-19 a thrust-to-weight ratio close to 1.

Both Mikoyan and air force pilots noted that the elevators were inefficient at supersonic speed. Trying to get the desired response, pilots would pull the stick back with greater force, increasing elevator deflection and hence drag; the aircraft would slow down and elevator efficiency increased abruptly, resulting in a sharp increase in *g* load. The only solution was to fit slab stabilisers, an approach similar to that practised by North American with the F-86E Sabre which had been in action in Korea since 1952. Yet, on 17 February 1954 the Council of Ministers issued a decree, ordering that the MiG-19 be put into production – regardless of the fact that the factory test programme had only just begun and the aircraft was not cleared for service entry by the air force.

Designing an all-flying horizontal tail with irreversible hydraulic actuators for the MiG-19 was difficult, in part because the Soviet aircraft industry and VVS had no experience with it. Only reversible actuators had been used before, and then only on subsonic MiG-15 and MiG-17 fighters. Conventional elevators are inefficient at supersonic speeds because their deflection does not increase the lift generated by the fixed stabilisers, and, in addition, pitch stability increased greatly at high speeds. Consequently, wing lift could not be used to the full during manoeuvres, and manoeuvrability and permissible *g* loads were greatly restricted.

Therefore, the second prototype MiG-19 (SM-9/2) rolled out in January 1954 was fitted with slab stabilisers mounted on a tubular axle passing through the aft fuselage. The horizontal tail was moved slightly up and its area decreased from 5.5 m^2 (59 sq ft) to 5.0 m^2 (53.76 sq ft). Other differences from the first prototype included a lengthened forward fuselage (which led to a reduction in air intake diameter), a third perforated ventral airbrake, a slightly shorter rudder with a trim tab, a larger fin fillet, engine cooling air intakes on the aft fuselage, spoilers on the undersurface of the wings mechanically linked to the ailerons, no wing pitots and no armament.

The ailerons were controlled by BU-13 actuators powered by a separate hydraulic system. The main hydraulic system acted as a backup, taking over automatically if the pressure in the stabiliser control circuit fell below 6398 kPa (928 psi). The stabilisers were similarly controlled by BU-14 actuators. The control system featured an artificial-feel unit, and to ease stick forces the stabilisers were adjusted by an electric mechanism with a stick-mounted switch. The stabiliser control circuit of the SM-9/2 also featured two electric emergency actuators with stick-mounted switches (they were later also fitted to the third prototype, SM-9/3).

The second prototype was armed with three NR-23 guns and had provisions for two or four FFAR pods. The avionics suite included an RSIU-4 Doob (Oak) UHF radio, an SRZO-1 IFF transponder, a Sirena-2 radar homing and warning system (RHAWS), an SRD-1M Konus (Cone) gun ranging radar linked to the ASP-5N gunsight (alternatively, the SRD-3 Grad (Hail) could be fitted) and the OSP-48 blind landing system.

The SM-9/2 did not make its first flight until after the state acceptance trials of the first prototype were completed, taking off on 16 September 1954 with G. A. Sedov at the controls. Mikoyan test pilots K. K. Kokkinaki, V. A. Nefyodov and G. K. Mosolov also participated in the factory test programme. In the third flight, when Kokkinaki was flying the aircraft, the stabilisers suddenly began oscillating uncontrollably and the aircraft started bucking crazily, throwing the pilot around. Despite the violent *g* loads and pain from collisions with equipment in the cockpit, Kokkinaki managed to land safely. Mosolov had a similar experience shortly afterwards, and regained control of the aircraft just 300 m (984 ft) above the ground. The incidents literally left both pilot and aircraft battered and bruised, and the aircraft suffered rivets popped and the skin buckled in several places.

The factory test programme was completed on 4 May after a total of 58 flights. The aircraft performed well, showing an excellent rate of climb – up to 180 m (590 ft) per second at low level. On one occasion, Mosolov attained Mach 1.462 in a shallow dive from 9300 m (30,511 ft). On 31 August 1955 the SM-9/2 began state acceptance trials, with S. A. Mikoyan as project test pilot. It soon became apparent that the fighter was too sensitive to stick inputs in the pitch channel at low speed, which was dangerous because the pilot could not keep up with the aircraft's oscillations and his corrective actions would only increase the amplitude of the oscillations.

To remedy this, the Mikoyan OKB developed the ARU-2A automatic flight control governor (*avtomat regooleerovaniya oopravleniya*) which adjusted stabilator deflection and stick forces depending on speed and altitude. At high speed, stick inputs caused less stabilator deflection than identical stick inputs at low speed and the aircraft handled almost identically in subsonic and supersonic modes. This allowed the maximum permissible *g* loads at supersonic speed and altitudes above 10000 m (32,808 ft) to be increased 1.8 times and the aircraft's manoeuvrability to be used to the full. The man behind the ARU-2A was A. V. Minayev, who went on to become one of Mikoyan's chief engineers and later Deputy Minister of Aircraft Industry.

The third prototype, SM-9/3 coded 'Red 3', was rolled out on 26 August 1955, but it was not until 27 November that Kokkinaki made the maiden flight. Outwardly, the aircraft differed from the SM-9/2 in reverting to the original short nose and large intake and having a shallow fuselage spine. It also had a larger nosewheel and improved armament consisting of three brand-new 30-mm (1.18-in) NR-30 guns and ORO-57K FFAR pods. The SM-9/3's weight of fire was doubled compared to the first prototype, amounting to 18 kg (40 lb).

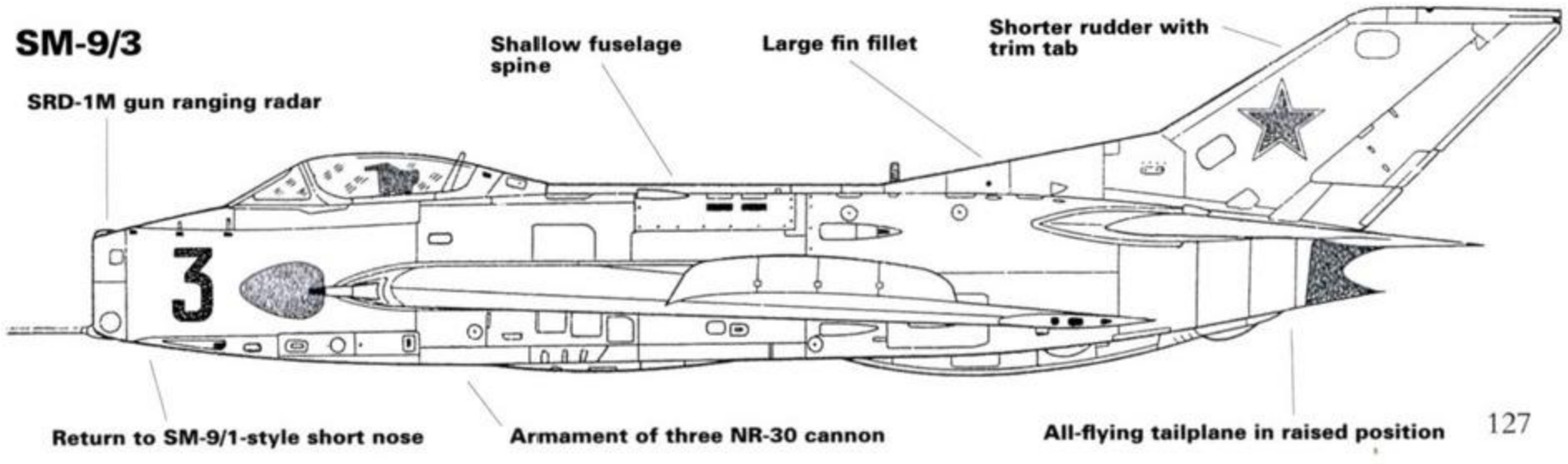
In addition to performance testing, the second and third aircraft were used for spinning trials. G. A. Sedov made a number of flights in 1954/55, and reported that spin recovery presented no problems. Air force pilots, however, thought differently. On one occasion in late 1955, NII VVS test pilot V. G. Ivanov was flying the SM-9/2 at 11000 m (36,089 ft). As he made a turn at supersonic speed, the aircraft suddenly started rolling and flicked into an inverted spin. After making several unsuccessful recovery attempts Ivanov radioed: "The aircraft is uncontrollable, I'm ejecting!" Still, he made one last attempt at 3000 m (9,842 ft), accelerating the engines to full military power, and the aircraft put its nose down into a vertical dive from which Ivanov managed to recover almost at zero level. It turned out that the stabilisers had been caught in the turbulent airflow separating from the wings in the turn, the result being similar to a deep stall.

Still, Mikoyan and NII VVS test pilots had a generally good opinion of the SM-9/2. *G* loads attained at 12000 m (39,370 ft) and 16000 m (52,493 ft) were 80 per cent higher than on the first prototype with fixed stabilisers and separate elevators.

However, as the trials progressed into 1956, on one occasion the SM-9/2 entered a spin from which it could not recover and test pilot Yuri A. Antipov had to eject. At 8000 m (26,246 ft), Antipov throttled back to minimum speed and initiated a left turn but the aircraft suddenly rolled to the right and became uncontrollable. Realising he was not going to make it, the pilot pulled the ejection seat visor but the canopy did not come off automatically. Using all his strength, Antipov pushed it open with his hands (later he learned that he used a force of about 150 kg/330 lb) and the seat fired.

The aircraft was totally destroyed, of course, but the flight data recorders survived. The cause of the crash was determined to be a slight deflection of the ailerons when they should have stayed neutral, and changes were made to the control system, canopy jettisoning system and ejection seat. Moreover, the loss of the second prototype triggered a large-scale spin investigation programme held by NII VVS and LII.

The trials continued with the third prototype. On another occasion, S. A. Mikoyan was to find out how the aircraft behaved in dead-stick mode. No sooner had he let go of the stick than the aircraft went crazy, pitching up and down with *g* loads of +/-2 and tossing the pilot about as if the seat belts were gone, until Mikoyan managed to regain control. More changes were made to the flight control governor



The SM-9/3 effectively set the configuration for the definitive production version, the MiG-19S. However, such was the urgency attached to the programme that the first production machines were based on the SM-9/1.

and this finally put an end to the problem.

Besides Mikoyan, test pilots G. T. Beregovoy, N. P. Zakharov and A. F. Nikolayev flew the third prototype during the state acceptance trials. The aircraft had excellent performance, reaching Mach 1.46; by comparison, the F-100 could only reach Mach 1.09.

In that same year, the SM-9/3 was used to test the APS-4 emergency stabiliser actuator which enabled the pilot to make it home with failed hydraulics. The electric emergency actuator was turned on automatically when hydraulic pressure fell below 4923 kPa (714 psi).

The third prototype was finally written off in an accident on 10 September 1956 when Sedov over-rotated it on take-off at 200 km/h (124 mph). "Aircraft tyres didn't last long in those days," Sedov recalled. "To reduce wear and tear on the tyres, the pilots devised a take-off technique with an unstick speed well below rotation speed, which was easier on the nosewheel. In that flight, the stabilisers unfortunately switched to electric control just as I rotated, and as the electric actuator works slowly I didn't manage to take corrective action." Sedov throttled back and the nose came down hard, bouncing several times; the nosewheel leg collapsed and the aircraft scraped along the runway in a shower of sparks. If the pilot had been less experienced the result could have been fatal. The SM-9/3 was by then a high-time airframe, so the aircraft was struck off charge, even though the damage was not critical.

The SM-9/3 was, in effect, the prototype of the MiG-19S which superseded the original production version of the MiG-19 at the assembly lines in Gorky and Novosibirsk.

I-1 (I-370)

As an insurance policy in case the Mikulin engine of the SM-9 did not come up to scratch, OKB-155 developed a parallel version powered by a single VK-7 afterburning turbojet. The aircraft, originally known as the I-370 but later redesignated I-1 (a.k.a. *izdeliye* '1'), looked a lot like the MiG-19 but incorporated some successful features of the MiG-17.

The VK-7 was to be the world's most powerful centrifugal-flow turbojet. While having the same dimensions and weight as the earlier VK-1F powering the MiG-17F, it would be 50 per cent more powerful, with a rating of 39.23 kN (8,818 lb st) dry and 51.49 kN (11,574 lb st) in full afterburner.

The basic design philosophy remained the same but the engine's main components were extensively modified. For example, an all-new centrifugal compressor with a so-called active wheel was used; it was 48 per cent more efficient than that of the VK-1F, for only a slight increase in engine diameter. For the first time on a centrifugal-flow turbojet, a supersonic diffusor with adjustable inlet guide vanes was used, increasing compressor efficiency. This, however, was the limit – the best one could get from a centrifugal compressor in terms of pressure ratio and air flow which directly affect thrust and specific fuel consumption.

The armament arrangement was inspired by the MiG-17. A single starboard 37-mm (1.45-in) Nudelman N-37D gun and two port-side 23-mm NR-23 guns were mounted on a common pallet under the nose which could be winched down for servicing and reloading. Unfortunately, this neat arrangement worked well only with centrifugal-flow engines which were impervious to gun blast gases. Axial-flow turbojets surged after ingesting gun blast gases, as was first evidenced by the MiG-9. On the MiG-19, therefore, the guns had to be relocated to the wingroots, complicating maintenance immensely.

The single-spar wings were identical to those of the MiG-19, with 55° sweep at quarter-chord, being internally braced and made of Elektron magnesium alloy castings and V95 aluminium alloy sheet. The forward fuselage was also borrowed from the MiG-19 with minor modifications. The aft fuselage (from frame no. 20 on), however, was completely different because of the different powerplant. It could be removed for engine maintenance or change.

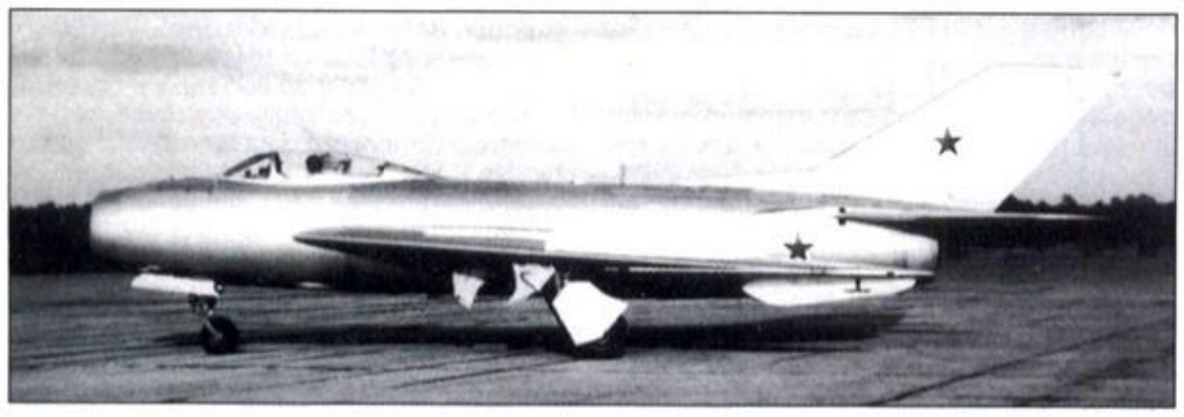
The mass-balanced ailerons had irreversible hydraulic actuators and the rudder was controlled manually by means of rigid linkages. At an early design stage, the aircraft had a T-tail but this was changed to a more conventional layout after the SM-2 prototype was test flown. The stabilisers were also swept back 55° at quarter-chord. Curiously, they were all-flying but still incorporated separate elevators (this unique combination was due to the fact that the definitive pitch control method had not yet been selected). The stabilisers were actuated by a Bu-27 hydraulic actuator and rotated around a transverse beam attached to the rear fuselage above the afterburner. The airbrakes were electrically actuated.

Since the single VK-7 turbojet had a smaller air flow than two AM-9Bs, air intake area was decreased by extending the intake lip forward. To ensure adequate directional stability, two ventral fins canted 45° outboard were fitted to the aft fuselage.

The hydraulically retractable tricycle landing gear was identical to that of the MiG-19. The aft-sliding cockpit canopy had a cast Elektron frame, and the fixed forward portion incorporated an electrically de-iced triplex bullet-proof glass panel. The cockpit was pressurised by engine bleed air and featured an automatic temperature control system.

The escape system included an ejection seat (designed in-house and based on those used in the MiG-15 'Fagot' and MiG-17) and a unique emergency braking system. When the pilot initiated the ejection sequence by pulling down a protective visor incorporated in the seat headrest, the canopy was automatically jettisoned regardless of the aircraft's attitude and the airbrakes were automatically deployed. Simultaneously, the emergency braking system was actuated, comprising three extra-strong parachutes.

The three fuel tanks located in the fuselage held a total of 2025 litres (446 Imp gal). The forward and centre tanks were rubber cells, while the aft fuel tank was integral. Additionally, two drop tanks could be carried under the wings.



The single-engined I-1 was loosely similar to the twin-engined SM-9/1, but had an unusual all-moving tailplane with elevators, and a longer nose. The three-cannon armament was housed in a drop-down tray under the intake, like that of the MiG-17.

Avionics included an ASP-4N gunsight linked to a Radal'-M gun ranging radar, an RSIU-3 UHF communications radio, an Oozel IFF set and an OSP-48 ILS receiver. The small antenna of the gun ranging radar was fitted flush with the intake lip.

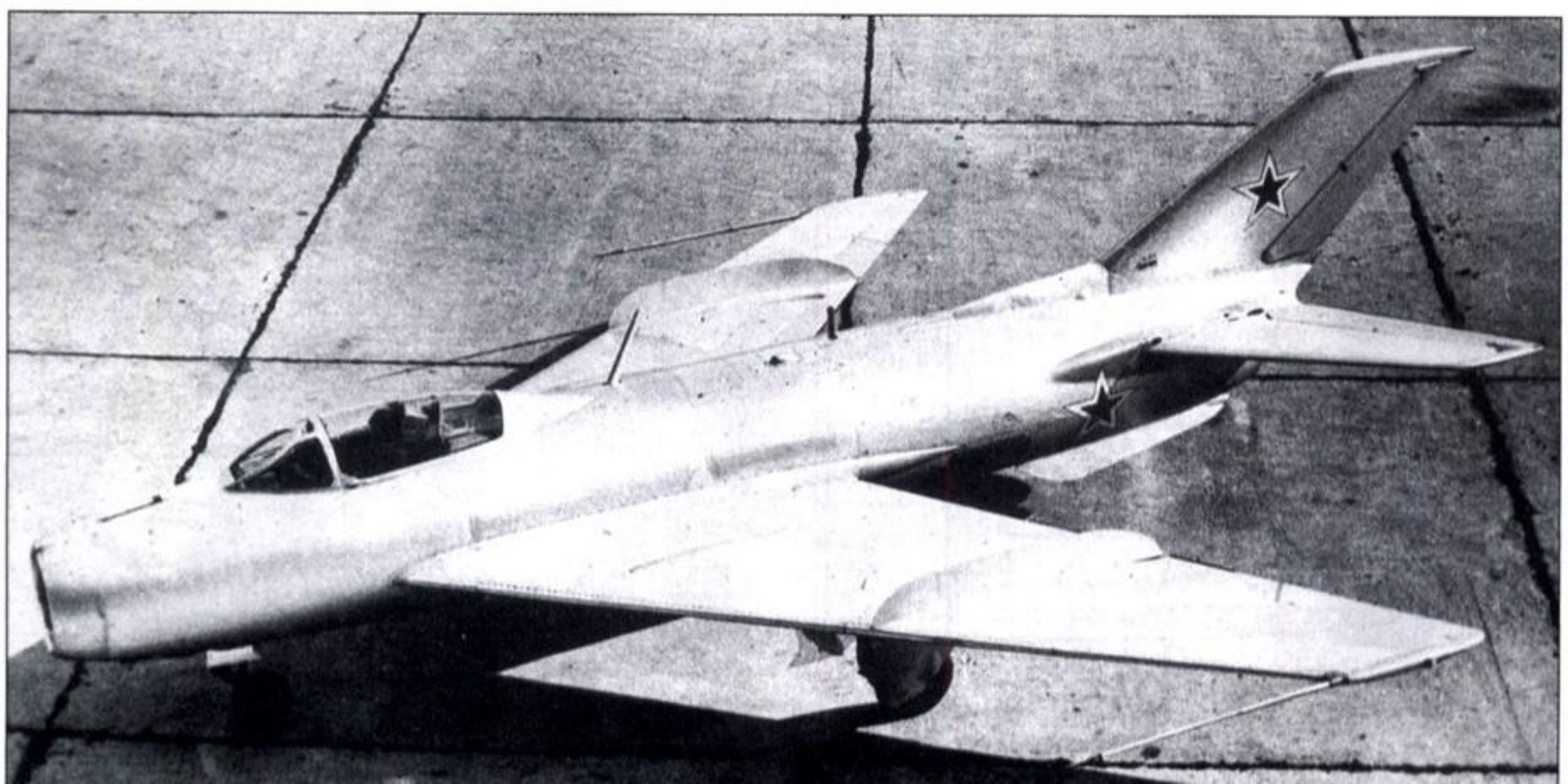
The VK-7 prototype began bench running in August 1952. It soon transpired that the engine failed to meet the design specifications, and Klimov set to work refining it. Meanwhile, the I-1 first prototype was completed at the Mikoyan experimental plant in 1953; however, the aircraft sat engineless for almost a year since the VK-7 still was not performing as it should. The flight-cleared engine was finally fitted in August 1954, but flight tests did not commence because more problems appeared – this time with the airframe and systems. By the end of the year the government lost patience and issued a decree, cancelling the VK-7 programme altogether.

Still, the I-1 did enter flight test. The belated first flight took place on 16 February 1955, with Mikoyan test pilot Fyodor I. Boortsev at the controls. The test programme was completed on 2 June 1955. A NII VVS test pilot made 13 flights on the prototype, reporting that the aircraft attained a Mach 1.334 top speed, remaining stable and controllable throughout.

Initially the I-1 was powered by an early-model VK-7 (c/n K-733) with a two-position hydraulically-adjusted nozzle, rated at 34.57 kN (7,771 lb st) dry and 51.34 kN (11,541 lb st) reheat. Later the prototype was refitted with an improved VK-7F (c/n K-338) developing 41.19 kN (9,259 lb st) dry and 61.49 kN (13,822 lb st) in full afterburner. These are Mikoyan OKB figures in both cases. According to the Klimov OKB, the VK-7F developed 43.15 kN (9,700 lb st) dry and 61.29 kN (13,778 lb st) in full afterburner.

Originally, the I-1's top speed was identical to that of the MiG-19 (1452 km/h; 902 mph). However, the uprated VK-7F with a turbine temperature of 800°C (1,472°F) increased top speed to 1510-1520 km/h (938-944 mph). The aircraft climbed to 5000 m (16,404 ft) in 1.15 minutes and to 10000 m (32,808 ft) in three minutes. Range with drop tanks was 2500 km (1,552 miles). Take-off run was only 464 m (1,522 ft) thanks to the powerful engine, and landing run was 730 m (2,395 ft). Handling during take-off, climb, descent and landing was extremely similar to the MiG-19.

However, the factory test programme was held just for the sake of experiment, since the VK-7 had been abandoned. Besides, the I-1 revealed few advantages over the MiG-19.



I-2

In an attempt to increase the I-1's speed, the aircraft was fitted with new wings featuring increased sweepback (57° at quarter-chord) but having an identical span. Redesignated I-2, the aircraft was tested but the results proved disappointing.

MiG-19 (*izdeliye* 59)

Even before testing of the SM-9/1 had been completed, the Council of Ministers and the Central Committee of the Communist Party issued a decree on 17 February 1954, ordering that the aircraft be put into production under the service designation MiG-19. Two aircraft factories – No. 21 in Gorky and No. 153 in Novosibirsk – were tasked with building the type; at the former plant it was referred to as *izdeliye* 59.

The Ministry of Aircraft Industry received a strongly worded order from the Council of Ministers to turn over the first 50 aircraft and 100 AM-9B engines manufactured according to OKB drawings (instead of production factory drawings as was customary), while the Ministry of Defence got similar orders to accept the aircraft.

In June 1955, 14 months after the SM-9/1's first flight, the VVS received the first two production aircraft. The MiG-19 quickly achieved initial operational capability. A formation of 48 aircraft participated in the Tushino air show on 3 July that same year, giving Western observers their first glimpse of the type.

After this the MiG-19 was allocated the NATO ASCC codename 'Farmer-A'. Initially, however, the aircraft was reported in Western magazines under various erroneous designations ranging from MiG-21 to TsAGI-418. The actual designation did not become known until a year later when four MiG-19s piloted by VVS inspector pilots put on a lively aerobatics display at the 1956 Tushino air show, with PVO (Air Defence Command) C-in-C Colonel General Yevgeni Ya. Savitskiy flying the lead aircraft. The performance was repeated at Tushino air shows for several years running.

Production aircraft differed from the prototype in having the N-37D guns replaced by a trio of NR-23s (two in the wingroots and one on the port side of the forward fuselage). Two BD-3-56 'wet' racks were fitted under the wings, able to carry either bombs or 760-litre (176-Imp gal) drop tanks. Two removable pylons could be fitted further inboard aft of the mainwheel wells for carrying ORO-57K FFAR pods for ground attack duties. Other differences from the SM-9/1 included a simplified canopy frame, the absence of wingtip pitot booms, the lack of blast shields on the forward fuselage sides near the wing guns and the addition of a Sirena-2 RHAWS.

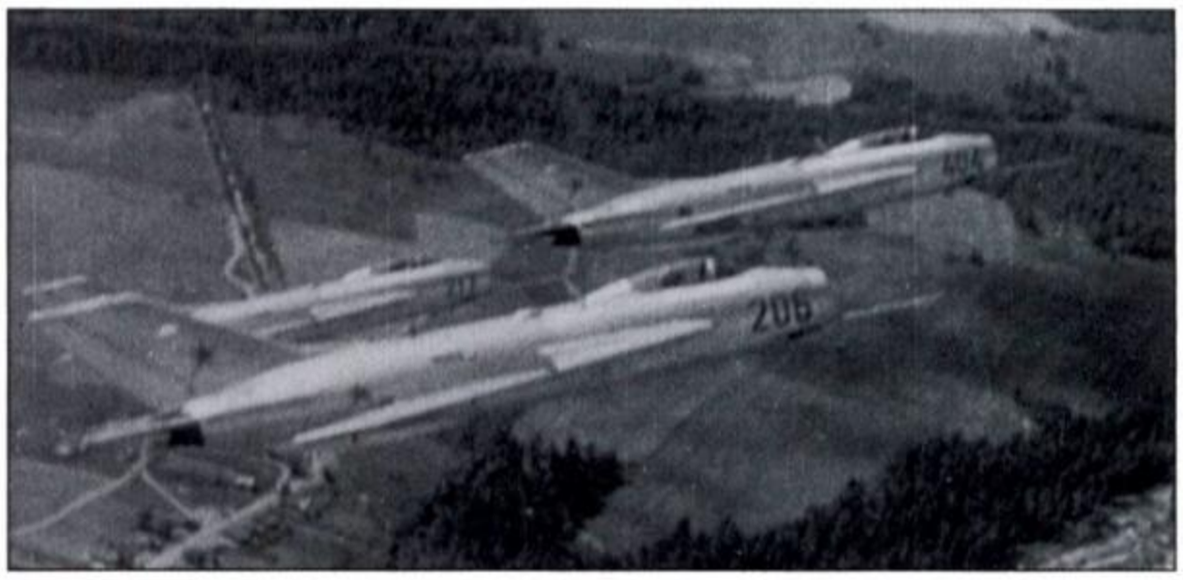
The production MiG-19's avionics and equipment included the ASP-5N gunsight linked to the Radal'-M (a.k.a. SRD-1) gun ranging radar, the RSIU-3 UHF communications radio and the OSP-48 ILS receiver. On early production aircraft the whip aerial of the radio was fitted on the starboard side aft of the cockpit. As on earlier Mikoyan jet fighters, the engines could be replaced easily by removing the entire aft fuselage. The MiG-19 was the first Soviet fighter to feature a brake parachute that reduced the landing run from 800 m (2,624 ft) to 600 m (1,968 ft).

The aircraft was none too popular with its pilots, the prime reason for its bad reputation being the tendency to blow up in mid-air. Discovering the cause took time because the explosions occurred unexpectedly, and certainly few pilots lived to tell the tale. Eventually the problem was traced to the fuel tanks located in the aft fuselage directly under the engines. Because of poor heat insulation the engines overheated, which could result in a fuel explosion. The situation was partially resolved by adding a metal heat shield between the engines and fuel tank no. 2, but still service pilots remained wary of the MiG-19.

Another problem was the poorly placed airbrakes. When deployed, they produced severe turbulence affecting the tailplane, and the aircraft would suddenly pitch up uncommandedly with high *g* loads. The pilots also disliked the MiG-19's high approach speed – 230 km/h (143 mph) versus the MiG-15UTI's 160 km/h (99 mph) – which slowed down conversion training a good deal because no trainer version of the MiG-19 was available.

Factory tests in 1955 had revealed major aerodynamic problems. The airflow around the rear fuselage was irregular, reaching supersonic speeds in some areas while remaining subsonic in others; this caused asymmetric distribution of shock waves. At indicated airspeeds of Mach 0.9 and higher, the aircraft grew directionally unstable and demanded excessive pilot inputs to keep it on the right track.

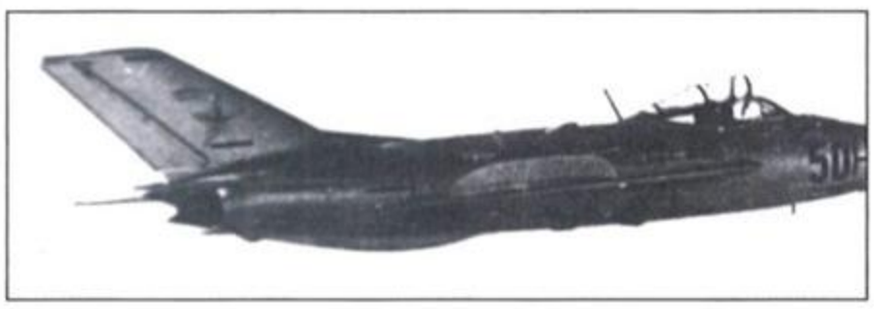
The problem was eliminated by designing a new and cleaner tail fairing terminating in a characteristic 'fork' between the engine nozzles. Six different versions were tried, the definitive one being



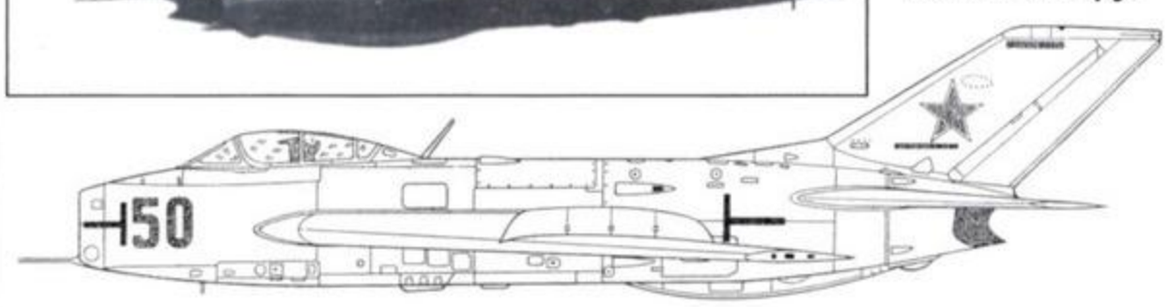
Above: A trio of production MiG-19s flies over the Russian countryside. Based, as they were, on the SM-2/1, the early MiG-19s had a short dorsal fin fillet and conventional tailplanes.

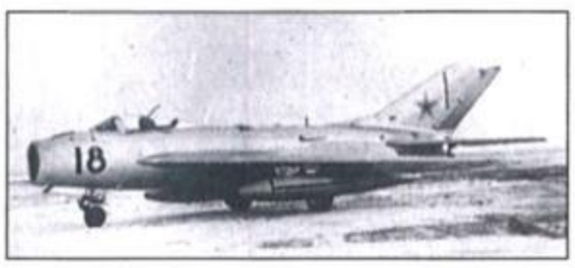
Right: This is the ejection seat from a MiG-19, displaying the face curtain which was incorporated into the headrest.

MiG-19 testbeds

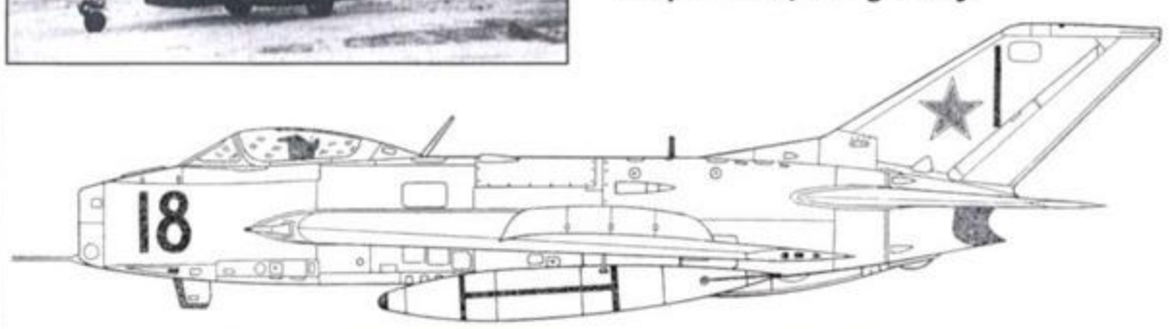


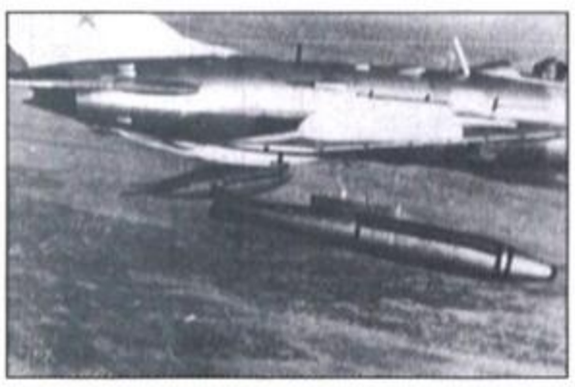
Left and below: This testbed was used for ejection seat trials, and was fitted with a revised canopy.

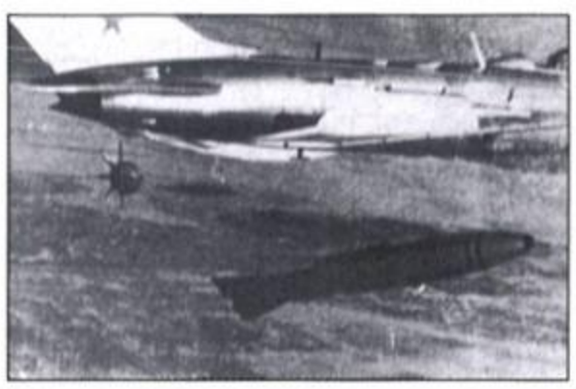




Left and below: 'Red 18' was used for drop tank trials and was fitted with a fairing aft of the nosewheel. The sequence at bottom shows the drop tanks falling away.

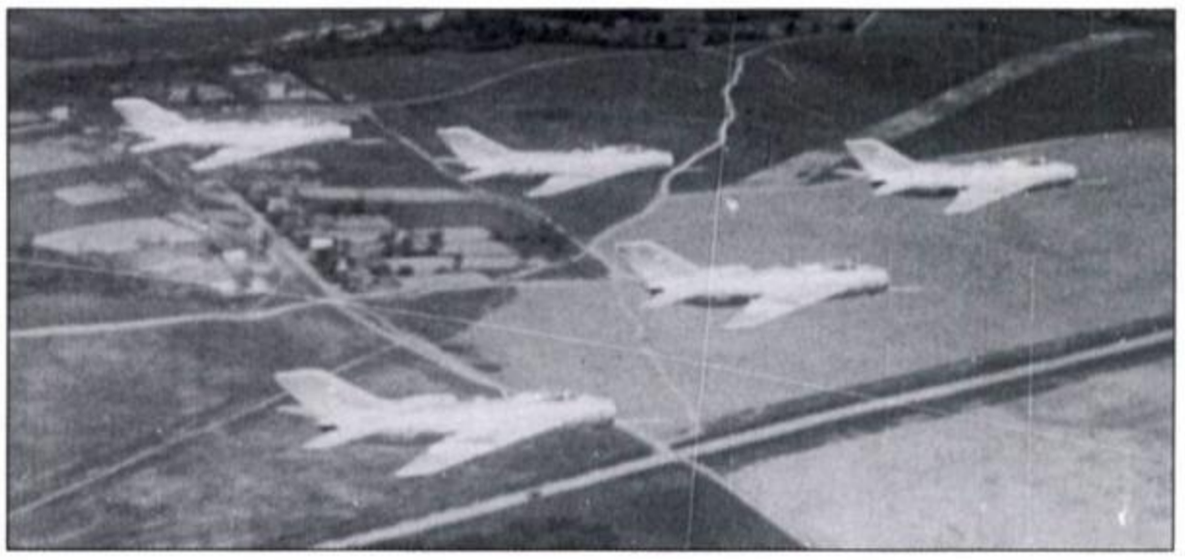






Above: MiG-19s entered service in large large numbers during 1956, pending the service entry of the definitive slab-tailed MiG-19S. Note the covered cannon and pitot.

Below: Five MiG-19s practise formation flying, possibly in preparation for the 1955 Tushino flypast when the type was revealed to the West.



In addition to the three NR-23 cannon, the MiG-19 was fitted with two underwing pylons for the carriage of bombs or fuel tanks. The first production variant was far from ideal, a function of it being rushed into service before development had been fully undertaken.

somewhat shorter and lighter than the intermediate ones and adopted for the production aircraft. Another measure in the same direction was the addition of vortex generators on the aft fuselage near the tailplanes.

A new avionics package was introduced in 1955, comprising the KUS-2000 airspeed indicator, the VD-20 altimeter, the TP-260 backup receiver and the new GIK-1 gyromagnetic compass with a combined compass/ARK-5 ADF dial.

Despite its shortcomings, the MiG-19 outperformed its US counterpart, the Super Sabre. The Soviet fighter had an excellent climb rate in its day – 180 m (590 ft) per second at 5000 m (16,404 ft) in full afterburner and 115 m (377 ft) per second at ground level at full military power (without afterburner). It climbed to 10000 m (32,808 ft) in 1.8 minutes in full afterburner or 2.3 minutes at full military power. The F-100 required four minutes to do the same; within this time, the MiG-19 could reach an altitude in excess of 15000 m (49,212 ft), climbing in full afterburner. The MiG-19 was faster – 1452 km/h (902 mph) versus 1215 km/h (754 mph) – and more manoeuvrable than the F-100. At a take-off weight 3000 kg (6,613 lb) heavier than its Soviet counterpart, the F-100 had a combat radius 200 km (124 miles) shorter. This comparison is particularly impressive when one considers that the MiG-19 prototype first flew a year before the XF-100.

New production versions began appearing soon, along with various experimental versions and testbeds that contributed immensely to the improvement of the production MiG-19, its systems and armament. For example, on one aircraft the standard KT-27 mainwheels fitted with drum brakes were replaced by KT-61 wheels with disc brakes that reduced the thermal load on the wheels during braking. Another aircraft had a new landing gear with KT-87 mainwheels.

In 1956 a production MiG-19 was fitted experimentally with an ARK-544 Ilim ADF (named after a Russian river). Three different aerial configurations were tried – a built-in aerial in the fin, a loop aerial buried in the fuselage and two strake aerials on the fuselage sides.

In the same year, another production aircraft was used to test the RUP-4 ILS computer (RUP = *reshayushcheye oostroystvo posahdki* – landing computer) coupled with the ARK-5 ADF and GIK-1 gyro compass. The system enabled the aircraft to navigate and make automatic approaches using marked beacons.

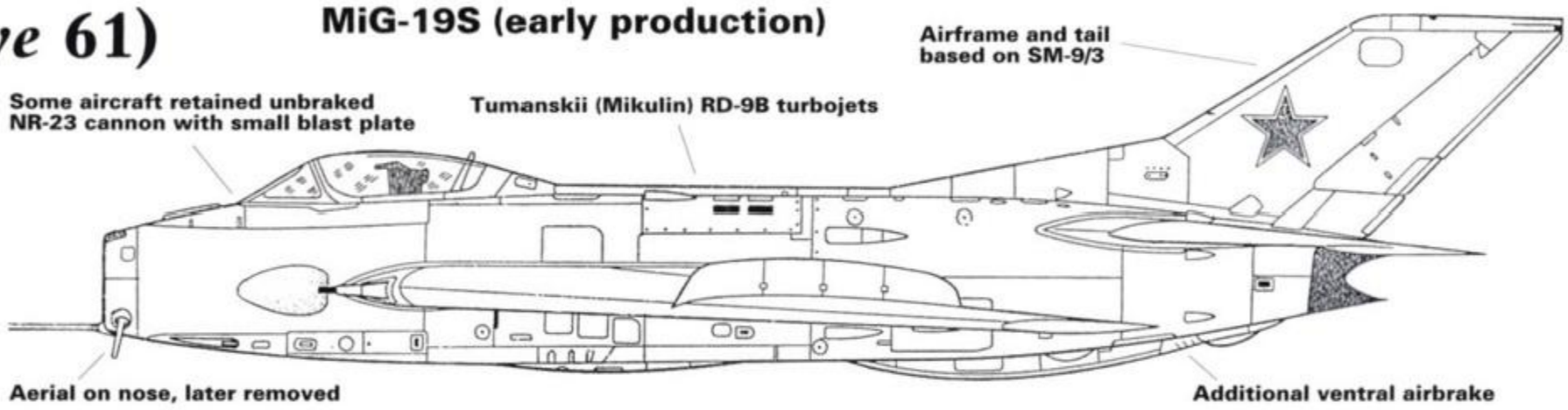
MiG-19S (*izdeliye* 61)

The MiG-19S superseded the initial production version on the production lines in Gorky and Novosibirsk in 1956 (in Gorky it bore the internal designation *izdeliye* 61). In addition to the introduction of stabilators replacing the original fixed stabiliser/elevator assemblies (hence the S for [*tsel'nopovorotnyy*] *stabilizahtor* – all-movable or slab stabiliser), it had numerous other improvements. A third (ventral) airbrake with an area of 0.45 m² (4.8 sq ft) was added, and 30-mm NR-30 guns with muzzle brakes replaced the original NR-23s. Two separate hydraulic systems were introduced, along with hardpoints for two 250-kg (551-lb) FAB-250 bombs or FFAR pods, a new SRD-3 Grad gun ranging radar and a new RSIU-4 UHF radio.

The new guns required changes to the gun mounts, ammunition feed mechanism, spent case ejectors and ammunition box in the fuselage. To prevent accumulation of gun blast gases in the gun bays, three vents were added in the upper bay covers. Drawings of the new gun installation were passed to the Gorky factory as early as 1954, with a view to building two prototypes and beginning state acceptance trials in 1955.

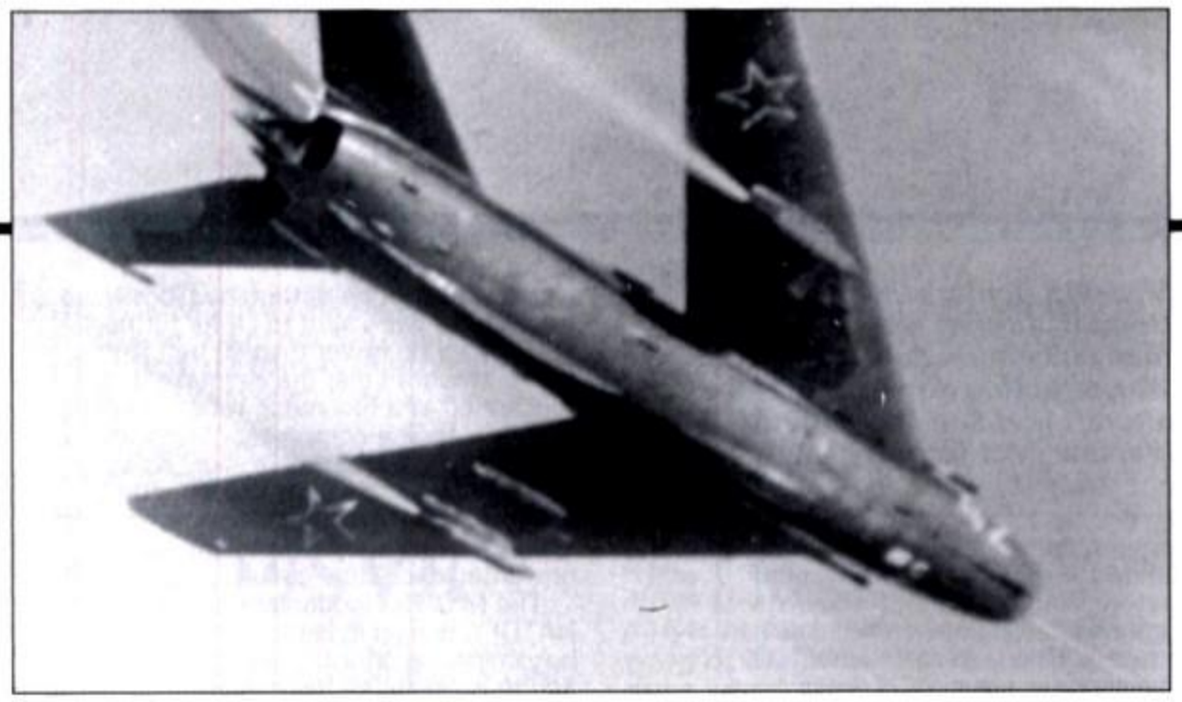
Additionally, the MiG-19S incorporated changes to the powerplant, control system, wheel brakes and brake chute, which in turn necessitated major changes to the fuselage and wing structure. The modifications enhanced the aircraft's manoeuvrability and eased maintenance.

MiG-19S (early production)

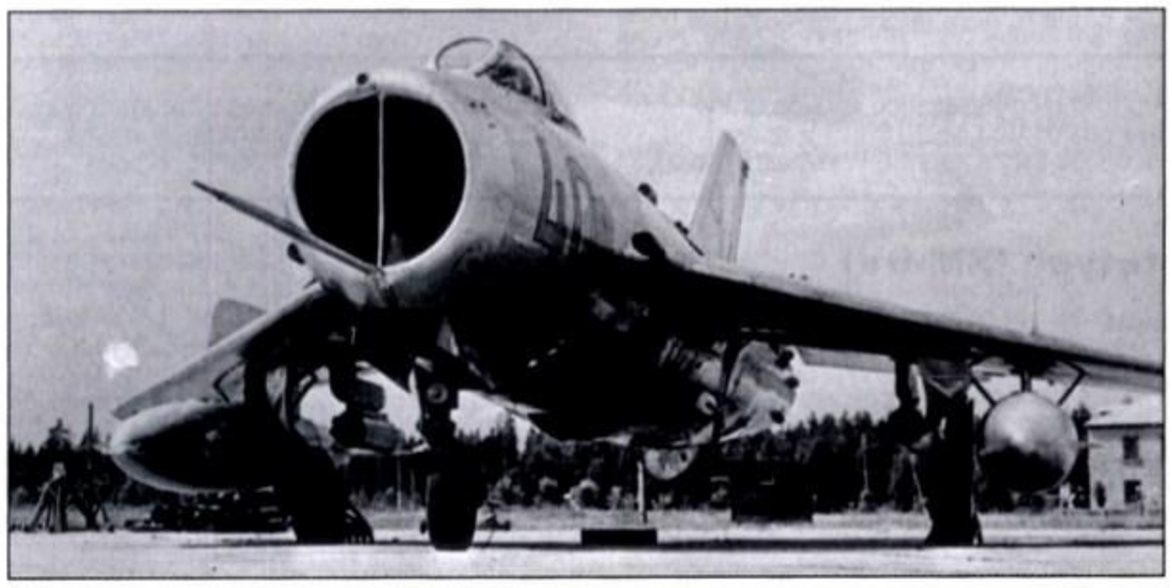

Some aircraft retained unbraked NR-23 cannon with small blast plate
Tumanskii (Mikulin) RD-9B turbojets
Airframe and tail based on SM-9/3
Aerial on nose, later removed
Additional ventral airbrake

Nonetheless, the aircraft's reputation did not improve, because the accident rate was alarmingly high. Many crashes were caused by faulty control system hydraulics. The manufacturing technologies still were not up to scratch, and minute metal shavings were often left behind in the hydraulic pipelines, clogging them and ruining the actuators, which could cause uncommanded stabilator deflection and loss of control. The ammunition links in the wings were known to burst during high-*g* manoeuvres. Fires occurred sometimes when leaking hydraulic fluid came into contact with the engines. The rubber of fuel cell no. 3 deteriorated on high-time aircraft,

A trio of MiG-19S day fighters launch from a typical Soviet airfield. The type became the principal tactical fighter of the late 1950s.



Above and below: The MiG-19S was used for both day fighter and ground attack duties. For the latter the ORO-57K rocket pod was used, initially carried on unusual backward-turned pylons. The three powerful cannon were useful strafing weapons.



causing fuel to leak into the engine bay. This would then evaporate and explode when the afterburners were engaged – unless ground crews were lucky enough to spot the trouble.

More improvements were gradually introduced. In 1957 the number of ORO-57K rocket pods was doubled (four pods with 32

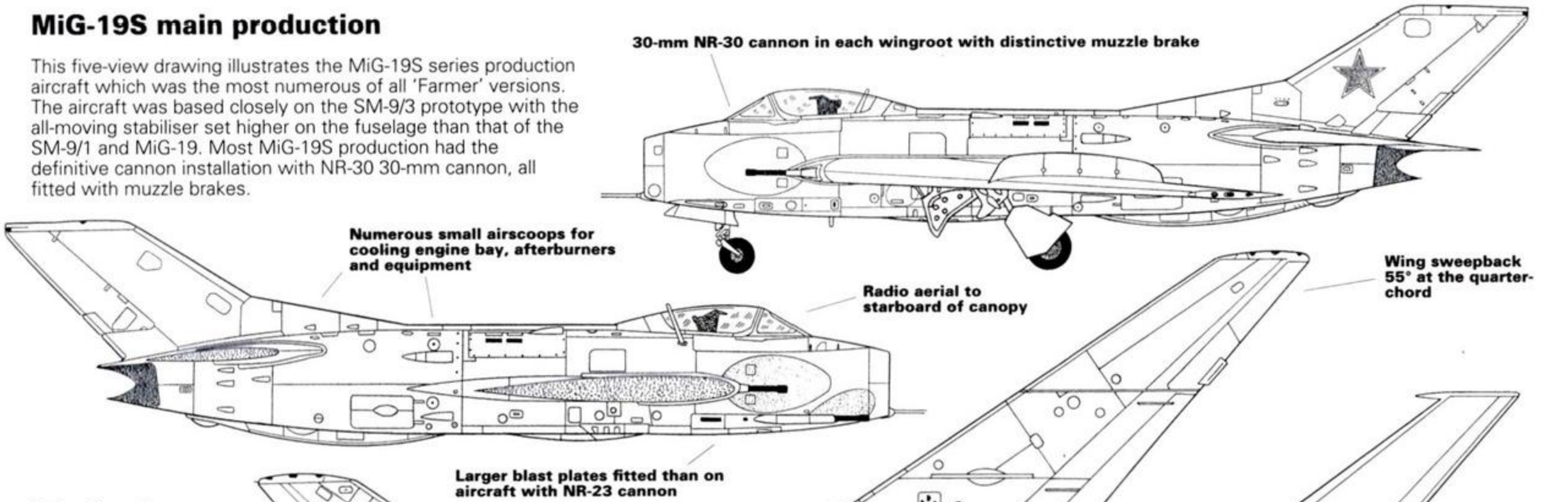
Above: MiG-19S fighters were supplied in sizeable numbers to Warsaw Pact and other 'friendly' nations. East Germany was a major recipient, one of its aircraft being seen here prior to a mission.

After their front-line days were over, MiG-19S airframes were used for a variety of tasks, some being converted to target drones. Here a cannonless MiG-19S is used during an NBC exercise.

This MiG-19S served with a fighter school after its front-line career had finished. It carries additional ORO-57K rocket pods on new pylons on the leading edge of the wing.

MiG-19S main production

This five-view drawing illustrates the MiG-19S series production aircraft which was the most numerous of all 'Farmer' versions. The aircraft was based closely on the SM-9/3 prototype with the all-moving stabiliser set higher on the fuselage than that of the SM-9/1 and MiG-19. Most MiG-19S production had the definitive cannon installation with NR-30 30-mm cannon, all fitted with muzzle brakes.


30-mm NR-30 cannon in each wingroot with distinctive muzzle brake
Numerous small airscoops for cooling engine bay, afterburners and equipment
Radio aerial to starboard of canopy
Wing sweepback 55° at the quarter-chord
Larger blast plates fitted than on aircraft with NR-23 cannon
Main wing pylon stressed for carriage of bombs or drop tanks
All-moving slab stabiliser with anti-flutter mass balances at tips
Twin airbrakes
Large wing fence at mid-span to prevent spanwise migration
Long, shallow ventral fin
4° 30′ anhedral wings
Inboard pylon for carriage of ORO-57K rocket pods

MiG-19S fighters like these East German aircraft were involved in many incidents during the Cold War, shooting down several Western aircraft that had strayed into Warsaw Pact territory.

ARS-57M FFARs) and electrically de-iced pitot tubes were introduced. An NI-50IM navigation display (NI = *nahvigatseeonnyy indikahtor*) was fitted for determining the aircraft's position. It worked at altitudes up to 20000 m (65,616 ft) and speeds up to 2000 km/h (1,242 mph), computing the distance covered by the aircraft.

The Svod (Dome) long-range navigation system developed for the MiG-19S gave it limited all-weather capability, automatically determining the azimuth and distance to ground beacons. It was fitted as part of a navigation suite including the SO-D IFF transponder and the GIK-1 compass.

On some production aircraft the SRD-3 gun ranging radar was replaced by an SRD-5 unit, which initially proved troublesome. During pre-delivery tests of a Novosibirsk-built MiG-19S equipped with the SRD-5, the factory test pilot discovered that the radar was prone to false target lock-ons. The cause could not be determined locally, so two aircraft were sent to LII for further tests. After no fewer than 80 test flights, it was discovered that the air intake duct functioned as a resonator, reflecting echoes from the engine compressor faces which the radar picked up with a slight delay and misidentified as a target lock-on. The problem was cured by installing horizontal splitter plates in the duct to spoil the unwanted oscillatory circuit.

The MiG-19S (codenamed 'Farmer-C' by NATO) was built in large numbers, becoming the principal supersonic tactical fighter in Soviet air force service in the late 1950s. It was also exported to numerous 'friendly nations' and licence-built in Czechoslovakia (as the Avia S-105) and China (as the Shenyang J-6, a.k.a. F-6). Poland's WSK PZL was also due to start licence-production but the plan never materialised.

MiG-19R (SM-9R)

A photo reconnaissance version of the MiG-19S designated MiG-19R (R = *razvedchik* – reconnaissance aircraft) was built in small numbers. It had the fuselage-mounted gun substituted by AFA-39 cameras and was powered by uprated RD-9BF-1 engines.

MiG-19SV (SM-9V)

In the early months of service the VVS was quite happy with the climb rate and service ceiling of the MiG-19 and MiG-19S. However, no sooner had the type entered service than Western nations began sending reconnaissance balloons *en masse* across the Soviet borders, followed by Boeing RB-47 Stratojet high-altitude reconnaissance aircraft. Soviet intelligence sources reported that Lockheed was working on a reconnaissance aircraft capable of flying at 25000 m (82,020 ft), which subsequently emerged as the (in)famous U-2.

No Soviet aircraft of the time could cope with intruders flying that high. Therefore, the Council of Ministers was quick to issue a decree, ordering the Mikoyan OKB to design and build a lightened high-altitude interceptor version of the MiG-19S designated MiG-19SV (V = *vysotnyy* – high altitude). Pursuant to the same decree, 100 aircraft were to be built in 1956 and retrofitted with a liquid-fuel rocket booster designed by the Glushenkov bureau.

The MiG-19SV prototype converted from the fourth Gorky-built production MiG-19S ('Red 14', c/n 61210104 – i.e., type 61, plant No. 21, batch 1, fourth aircraft in batch) was ready for testing in 1956. It was powered by experimental uprated RD-9BF engines with fixed-area nozzles of 535-mm (21-in) diameter. Dry thrust was increased 10 per cent by increasing the turbine temperature to 730°C (1,346°F) and modifying the flame stabilisers. The afterburners were also modified. All this increased the aircraft's service ceiling by 500-700 m (1,640-2,296 ft) but pushed the engines to their limit, reducing reliability greatly and causing critical heating of the neighbouring elements of the airframe.

Installation of the hotter engines required better cooling of the aft fuselage interior, so additional air scoops were fitted to upper aft fuselage. Other changes associated with the high-altitude intercept role included a flap take-off setting of 10° instead of 15° (this setting was used to increase wing lift at altitudes above 15000 m/49,212 ft and speeds below Mach 0.9 – for the first time on a Soviet fighter). The RV-2 radio altimeter, brake chute, fuselage-mounted gun and armoured seat back were removed to reduce weight. To make up for the lack of the brake chute, the standard KT-37 mainwheels with drum brakes were replaced by KT-61 wheels with cerametallic disc brakes which were more reliable and less prone to overheating.

Despite the pressurised cockpit of standard aircraft, the MiG-19SV's mission required additional safety measures and life support equipment. The latter included the KKO-1 oxygen system with increased oxygen pressure and the VSS-04A pressure suit. This was a must because decompression at high altitude, even the tiniest crack in the canopy, meant instant death for the pilot. The suit helped the pilot survive an ejection at high altitude and speed.

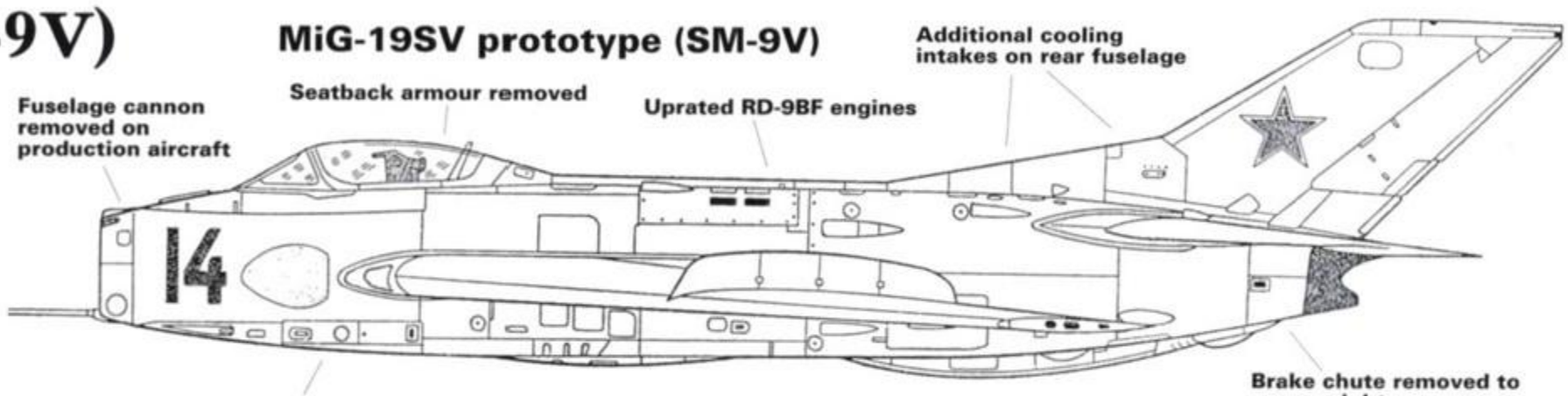
The leading engineers of OKB-155, including Artyom I. Mikoyan, gave top priority to the pressure suit design. Test pilots Konstantin K. Kokkinaki and V. A. Nefyodov tested the VSS-04A suit in a pressure chamber and later in real flight under the supervision of project engineer V. A. Arkhipov. The results were disappointing: the suit was poorly ventilated and bulky, impairing the pilot's movements. However, a much-improved VKK-2 suit was developed, building on this experience. It was deflated and did not complicate flying in normal flight when the cockpit was pressurised. In the event of decompression the suit inflated instantly, compensating for the loss of pressure. Kokkinaki tested the suit in a pressure chamber at simulated altitudes of up to 25000 m (82,020 ft); for the first time in the USSR, such an altitude had been simulated.

The new suit was quickly flight tested by Mikoyan test pilots G. A. Sedov, K. K. Kokkinaki and G. K. Mosolov, and air force pilots S. A. Mikoyan (the designer's son), V. P. Vasin and V. S. Ilyushin (the son of Sergei V. Ilyushin, and later a test pilot with Sukhoi), and entered production with minor modifications, staying in service until the early 1990s. It was complemented shortly after by the GSh (*ghermetichnyy shlem*) pressurised helmet; the suit and helmet enabled the pilot to work normally at altitudes up to 24000 m (78,740 ft).

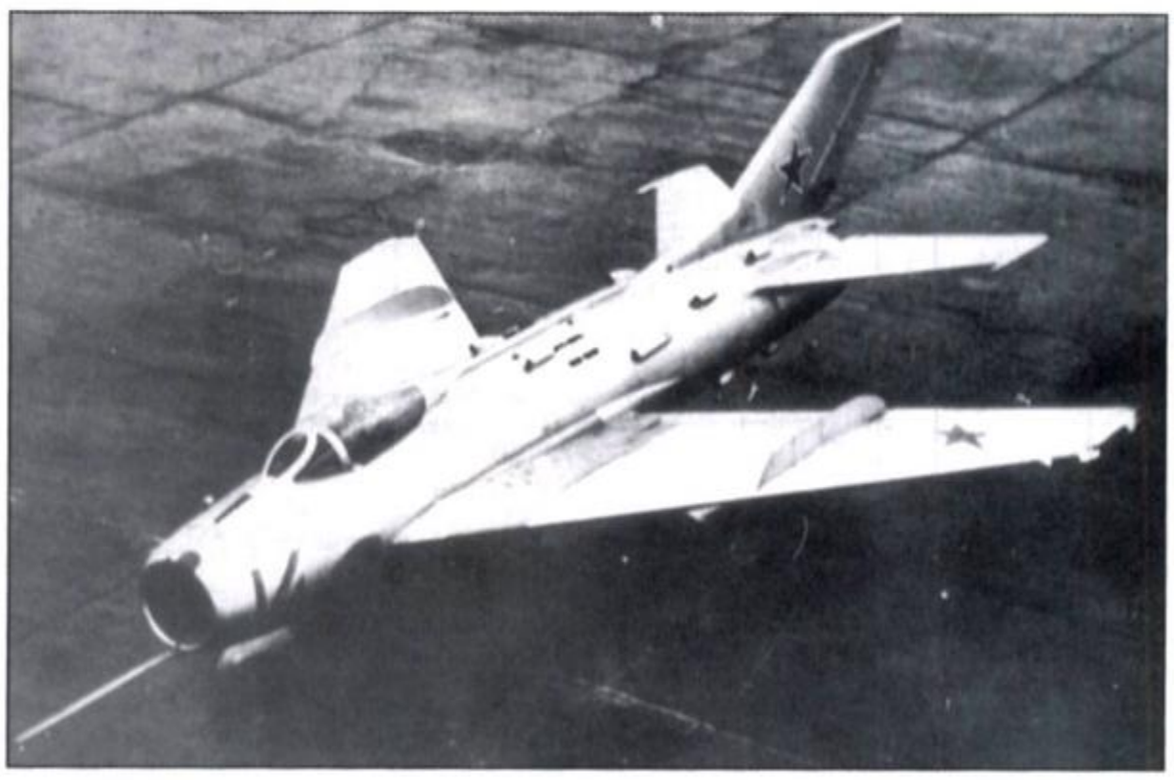
Factory tests of the SM-9V were performed by Mosolov and Nefyodov under the supervision of project engineer Arkhipov, after which the aircraft was turned over to NII VVS for further testing. The SM-9V had a service ceiling of 18500 m (60,695 ft) rather than 20000 m (65,616 ft) as per design requirements, and a top speed of 1572 km/h (976 mph) or Mach 1.48 at 11000 m (36,089 ft). On 6 December 1956, NII VVS test pilot N. I. Korovushkin set an altitude record on one of the SM-9V prototypes, attaining 20740 m (68,044 ft) in a zoom climb.

The test report said that "the MiG-19SV is virtually identical in handling to the standard MiG-19S but more stable and easier to fly at low speeds (350-380 km/h)

MiG-19SV prototype (SM-9V)


Additional cooling intakes on rear fuselage
Seatback armour removed
Uprated RD-9BF engines
Fuselage cannon removed on production aircraft
14
Wingroot cannon removed on prototype aircraft
Brake chute removed to save weight

'Red 14' acted as the prototype for the MiG-19SV high-altitude fighter, being converted from an early production MiG-19S. In addition to the weight-saving measures and uprated engine, the flap settings were changed to give greater lift at high altitudes.



This view of a MiG-19SV on display at the Khodynka museum highlights the additional airscoops around the rear fuselage. In service, many MiG-19SVs were fitted with revised afterburners or further uprated engines.

[217-236 mph]." The type entered limited production at one of the two plants building the MiG-19, and a number of MiG-19S fighters were converted to MiG-19SV standard.

RD-9BF engines fitted to production MiG-19SVs had a marginally smaller nozzle diameter (498 mm/19.6 in versus 535 mm/21 in on the prototypes). Some aircraft were powered by RD-9BF-1 engines with a revised afterburner or RD-9BF-2s uprated to 32.36 kN (7,275 lb st). Operational experience showed that the main shortcoming of the RD-9BF was its tendency to flame out at altitudes approaching the aircraft's service ceiling. Production MiG-19SVs had the take-off setting of the flaps further reduced to 8°, which increased wing lift at altitudes above 18000 m (59,055 ft).

The Globus IFF transponder was specially developed for the MiG-19SV in 1956. It worked with ground radars in 3-cm, 10-cm and 35-cm wavebands, transmitting the aircraft's individual callsign and altitude, and also distress signals. However, it is not known if this equipment was actually fitted to production aircraft.

MiG-19SVK

Experiments aimed at increasing the SM-9V's service ceiling continued at LII in 1957. Major structural modifications were made to the MiG-19SV prototype ('Red 14') as recommended by the Central Aero- and Hydrodynamics Institute (TsAGI). Wing span and area were enlarged by fitting an extended cambered leading edge outboard of the boundary layer fences, thus creating a prominent dogtooth, and new extended wingtips with a modified airfoil.

Wing span was 10.3 m (33 ft 9.5 in) instead of 9.0 m (29 ft 6.3 in) on the standard aircraft, aspect ratio was 3.8 vs 3.24, and wing taper was 3.4 vs 3.04. Wing area was increased from 25.16 m² (270 sq ft) to 27.7 m² (298 sq ft). Wing chord at the roots remained unchanged at 4.19 m (13.5 ft), decreasing from 1.378 m (4 ft 6.5 in) to 1.239 m (4 ft 0.5 in); mean aerodynamic chord (MAC) decreased accordingly from 3.023 m (9 ft 11 in) to 2.963 m (9 ft 8.6 in).

(**Note:** According to some documents, 'Red 14' was initially fitted only with the new wingtips, increasing wing span by 2.013 m (6 ft 7.5 in) and wing area by 2 m² (21.5 sq ft). Later, the span was slightly reduced concurrently with the installation of the extended leading edge; thus, wing area was increased by a further 0.54 m² (5.8 sq ft) despite the reduction in span.)

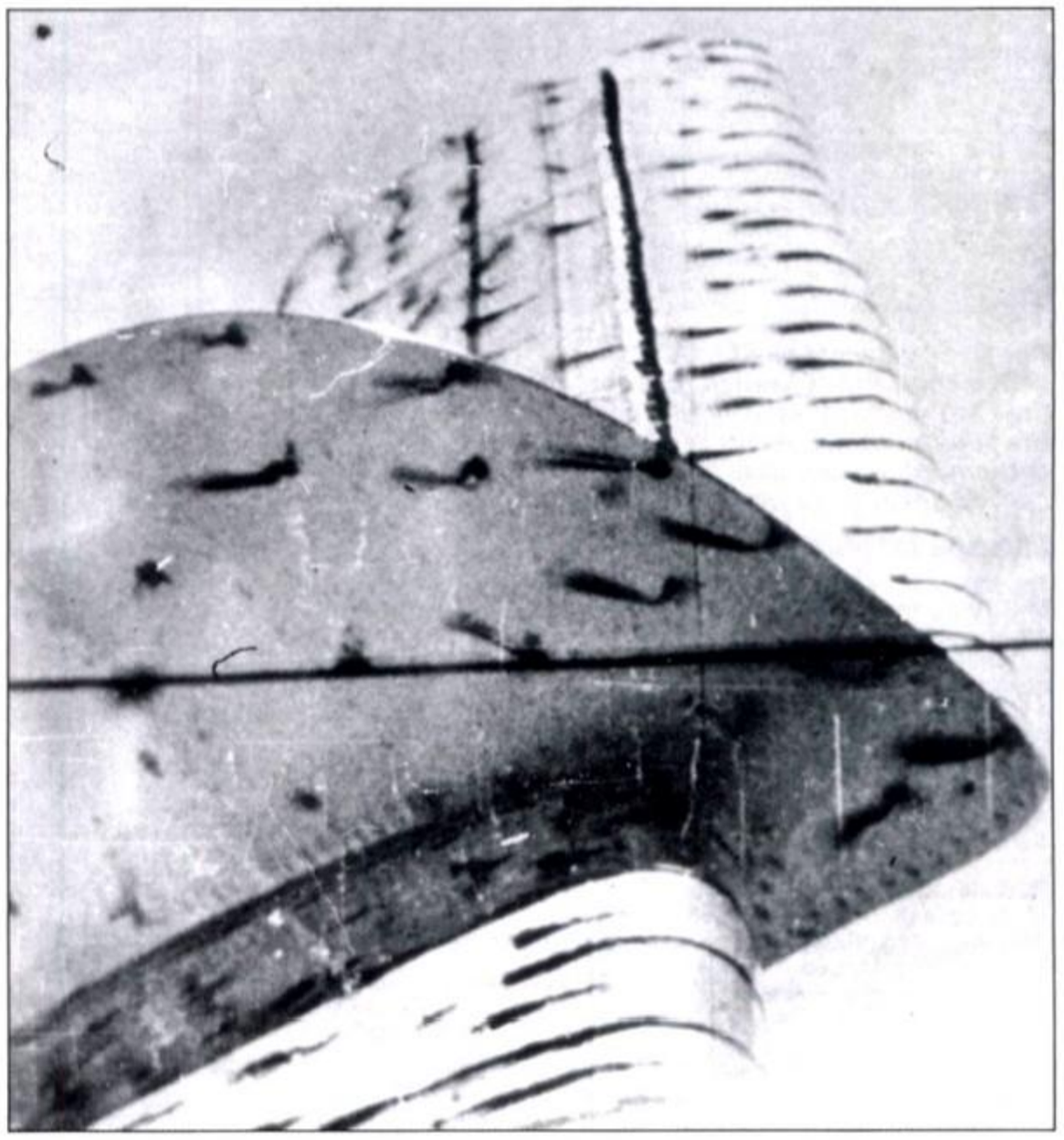
The converted aircraft was redesignated MiG-19SVK (K = *[novoye] krylo* – new wings) and recoded 'Red 644'. The modified wings gave greater lift and had a better lift/drag ratio at high Alpha. To reduce weight the wing guns and their ammunition were removed; however, additional equipment had to be installed, and the bottom line was that the empty weight of the aircraft increased by 65 kg (143 lb).

The MiG-19SVK was test flown by V. P. Vasin (leading project pilot) and V. S. Ilyushin. Originally, the aircraft was powered by RD-9BF engines (c/ns G631013 and G631033), replaced in early 1957 by RD-9BF-1s (c/ns 6506 and 6511). With the latter powerplant, empty weight was 7250 kg (15,989 lb). With standard wings the SM-9V's centre of gravity was located at 43.7 per cent MAC; after the conversion, however, it moved forward to 35 per cent MAC. Prior to the first flight a speed limit of Mach 1.3 or 444 kt (800 km/h; 497 mph) IAS and a *g* limit of 5 were imposed on the aircraft.

Tests showed that with RD-9BF engines, the MiG-19SVK had a service ceiling of 19100 m (62,664 ft) compared to 18800 m (61,679 ft) with standard wings; with RD-9BF-1s the service ceiling was 18900 m (62,007 ft) compared to 18550 m (60,859 ft) with standard wings. On 29 April 1957, V. P. Vasin attained a top speed of 1420 km/h (882 mph) at 16250 m (53,313 ft) on the RD-9BF-powered MiG-19SVK with a 6130-kg (13,514-lb) TOW. In a subsequent test flight with RD-9BF-1 engines and a 6430-kg (14,175-lb) TOW on 17 May, speed at the same altitude dropped to 1275 km/h (791 mph).

Vasin reported that the MiG-19SVK was no different from the standard aircraft as regards piloting techniques, and was "easier to fly at 320-380 km/h (177-211 kt) IAS, lacking the [standard aircraft's] tendency to pitch up and bank." Nor had take-off and landing performance changed.

Thus, the increase in service ceiling was only 300 m (984 ft) rather than the anticipated 1000 m (3,280 ft). The basic aircraft had reached its limit. However, several liquid-fuel rocket boosters were by then approaching the test stage and could be fitted to the MiG-19 in future to increase total thrust at high altitude. This would not only boost the service ceiling but give a burst of speed when necessary, and the Mikoyan OKB decided to concentrate on this new and promising feature.



Extensively covered in wool tufts to allow the observation of airflow patterns, this is the extended outer wing of the MiG-19SVK. The longer span and additional leading-edge area did little to improve service ceiling.

MiG-19S minor variants

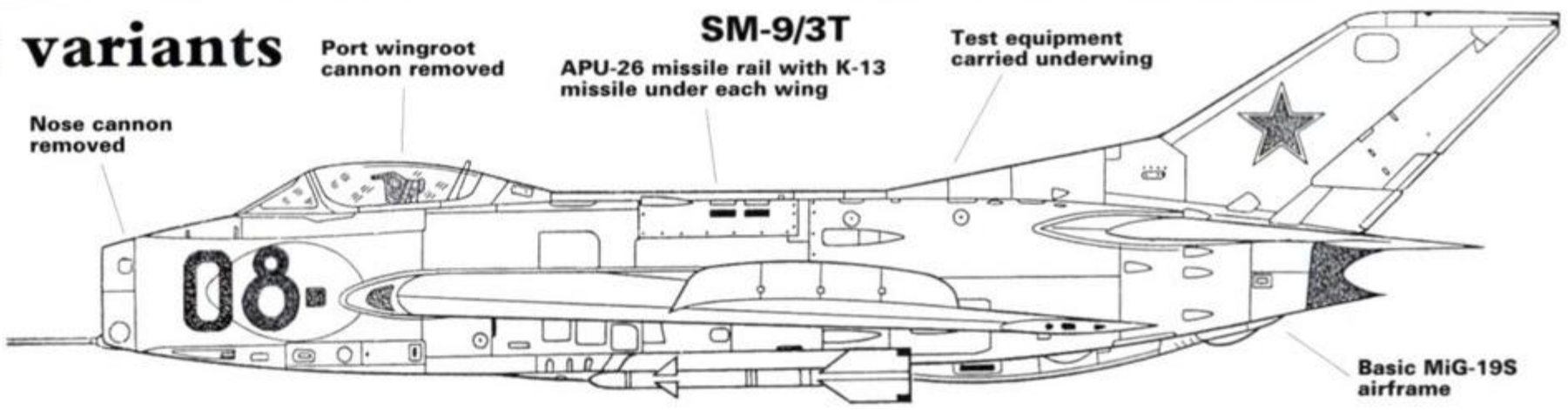
MiG-19S with VK-65 remote astrocompass

One production MiG-19S was experimentally fitted with the VK-65 remote astrocompass for determining true heading and following predetermined headings. The compass worked between 40° and 90° northern latitude if the sun was up to 70° above the horizontal plane of the aircraft.

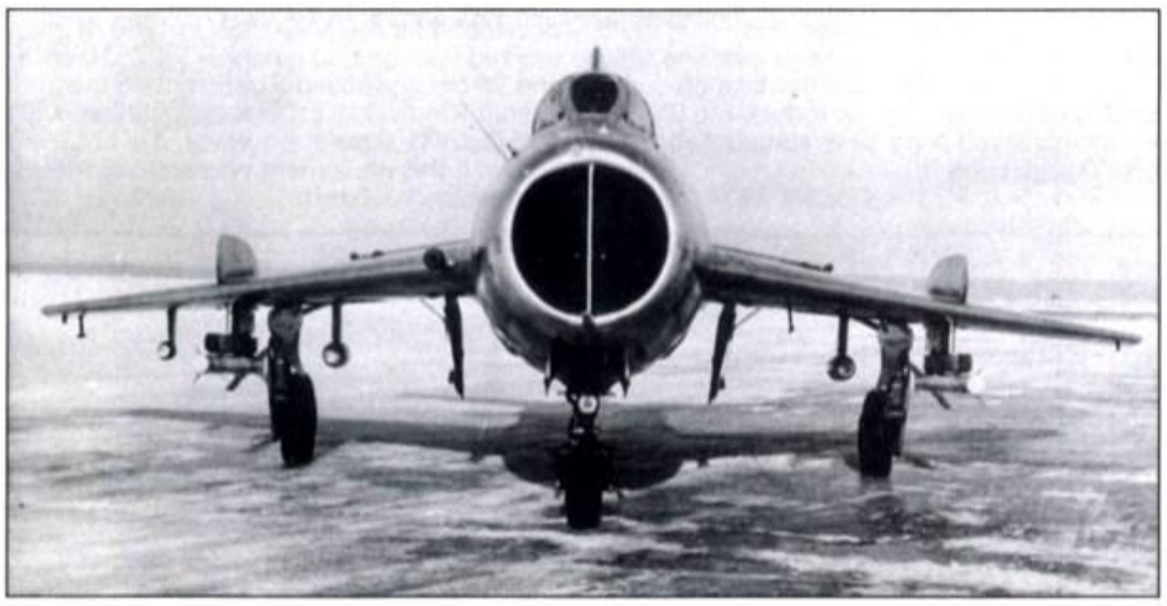
MiG-19S with AP-28 autopilot

In 1957-58 Mikoyan tested a MiG-19S fitted experimentally with an AP-28 autopilot in place of the fuselage-mounted gun. The autopilot facilitated flying, especially in IFR conditions, and would maintain the mode the aircraft was in prior to this (i.e., climb, descent or level flight); it could be changed by means of the autopilot's formation-keeping control handle. The autopilot also incorporated a 'panic button' feature, automatically bringing the aircraft into straight and level flight from any attitude should the pilot become disoriented.

The yaw, pitch and roll damping, and autostabilisation features were tested and found satisfactory; the aircraft's handling had improved in all modes, including aerobatics. Originally, the AP-28 was rigidly connected to the control circuits; later, isodromic feedback was introduced in the pitch and roll channels. The revised AP-28A autopilot successfully passed state acceptance trials in 1959 and was fitted to production aircraft from that year onward.



Unusually coded with a yellow number, the SM-9/3T was a weapons testbed for the K-13 missile, copied from the US AIM-9B Sidewinder.



The front view of the SM-9/3T shows the APU-26 launch rails for the K-13 missiles. Also visible are the additional pylons for test equipment, presumably cameras, carried under the wing.

MiG-19S (SM-9/3T)

The Mikoyan OKB experimented with the MiG-19's armament as well. Early-model AIM-9 Sidewinder IR-homing AAMs captured in Korea were obtained via mainland China in 1958, and a reverse-engineered version soon entered production in the USSR as the K-13 (AA-2 'Atoll'). The missile was intended both for operational fighters and for new ones then under development.

In February 1959 a Novosibirsk-built production MiG-19S was converted into a weapons testbed designated SM-9/3T. Unusually, the aircraft was coded 'Yellow 08' (only Yakovlev aircraft wore yellow tactical codes at the time). Two K-13 AAMs were carried on APU-26 missile rails (APU = *aviatseeonnaya pooskovaya oostanovka* – aircraft-mounted launcher) attached to pylons fitted instead of the usual drop tank hardpoints. A security system ensured that the missiles could only be fired when the landing gear was up.

When powered by the RD-9BF-1 engine, with revised afterburner, the MiG-19S became the MiG-19SF. This is a Czech air force example.

The tests commenced on 11 February 1959, when Aleksandr V. Fedotov made the first flight. The rest of the programme, however, was performed by another Mikoyan test pilot, Pyotr M. Ostapenko. The final flight was made on 3 March. The launch of the K-13 and its performance at the initial trajectory stage were examined, as well as the effect of the missile's exhaust on the fighter's engines. Top speed with two missiles was Mach 1.295 at 10800 m (35,433 ft) and 910 km/h (565 mph) at 17600 m (57,742 ft). The missiles had no adverse effect on the aircraft's handling.

MiG-19SF tactical fighter

A small number of MiG-19S fighters was built with RD-9BF-1 engines, three Nudelman-Richter NR-30 guns and a reduced empty weight. This version was known as the MiG-19SF.

In the late 1960s the North Vietnamese air force used an upgraded version of the MiG-19SF armed with two IR-homing R-3S AAMs.

SM-7

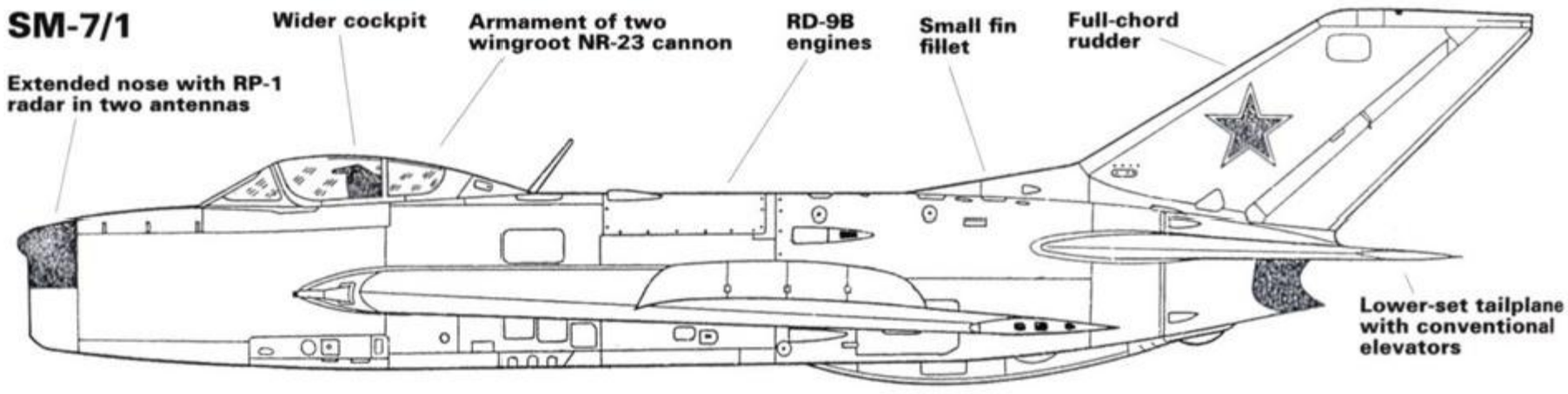
Pursuant to a decree of the Council of Ministers dated 15 August 1953 and a MAP directive dated 26 August 1953, the Mikoyan OKB worked in parallel on an all-weather interceptor while designing the basic tactical fighter. The project was finalised in the same year.

The SM-7, as the interceptor was designated, differed from the SM-9 in many respects. The SRD-1M Konus gun ranging radar was replaced by an RP-1 Izumrood-1 (Emerald) radar (RP = *rahdiopritsel* — literally 'radio sight') in a separate bay for ease of maintenance; consequently, the forward fuselage up to frame no. 9 had to be redesigned. The inlet ducts were recontoured and their cross-section area enlarged.

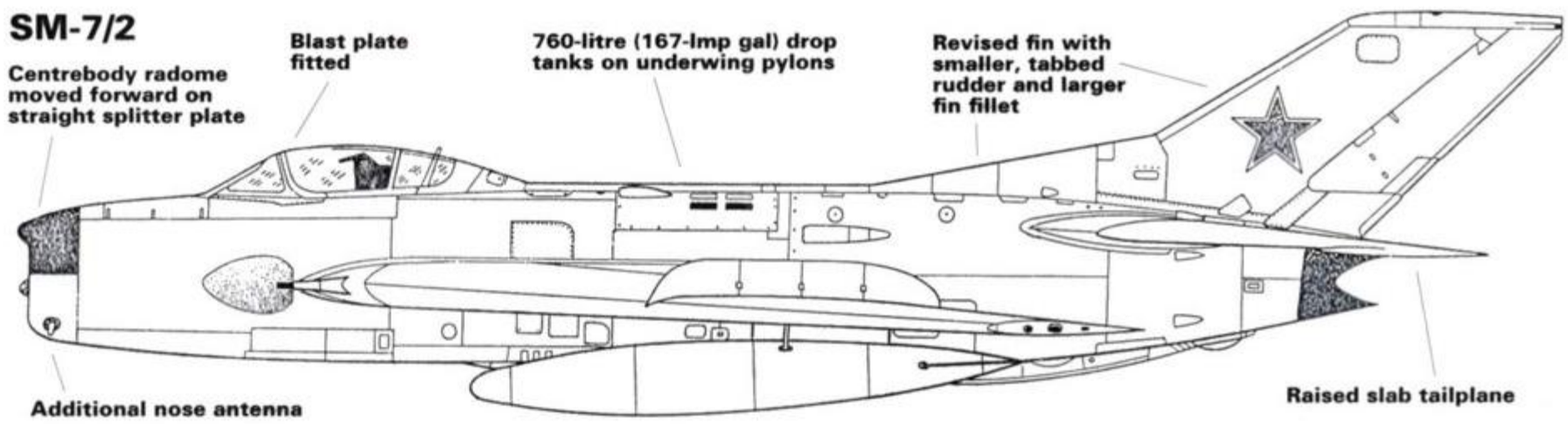
The Izumrood-1 radar was linked to the ASP-5NM gunsight and had two scanning aerials: the AR-18-16 transmitter aerial in a hemispherical radome in the centre of the air intake and the AR-18-1 receiver aerial in a large dielectric fairing incorporated into the upper part of the intake lip. It swept the area ahead of the fighter with a narrow beam, displaying all targets on the radar screen and tracking them automatically. Maximum detection range for a target with a radar cross-section (RCS) of 16 m² (172 sq ft) was 12 km (7.45 miles) and maximum tracking range was 2 km (1.24 miles).

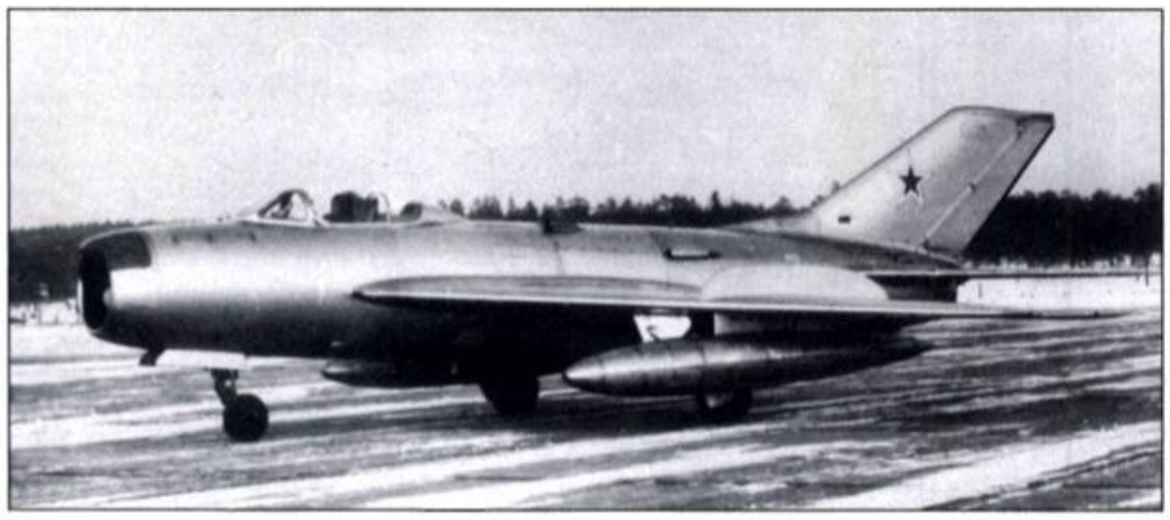
The cockpit was widened and the instrument panel reconfigured; this was made possible by the redesigned nose section. The ejection seat with a face protection visor was adjustable to fit pilots of different height, with three fixed positions and a travel of 120 mm (4.7 in). An armour plate 16 mm (0.62 in) thick was installed behind the seat to protect the pilot, ejection seat guide rails and ejection gun.

SM-7/1


Wider cockpit
Armament of two wingroot NR-23 cannon
RD-9B engines
Small fin fillet
Full-chord rudder
Extended nose with RP-1 radar in two antennas
Lower-set tailplane with conventional elevators

SM-7/2


Blast plate fitted
760-litre (167-Imp gal) drop tanks on underwing pylons
Revised fin with smaller, tabbed rudder and larger fin fillet
Centrebody radome moved forward on straight splitter plate
Additional nose antenna
Raised slab tailplane



The fuselage-mounted gun was removed, leaving two wing-mounted NR-23 guns with 120 rpg; the ammunition belts were placed in modified bays located in the wing leading edges. Two RO-57-8 (ORO-57K) FFAR pods with eight ARS-57 rockets each could be carried under each wing. Two 760-litre (167-Imp gal) drop tanks could also be carried.

The nozzle actuator cooling intakes on the rear fuselage were modified to improve efficiency. The RSIU-3M UHF radio and ARK-5 ADF now had a common aerial; similarly, the DGMK-5 gyro compass and ARK-5 ADF had a combined indicator. An MRP-48 marker beacon receiver, an Oozel IFF set, a Sirena-2 RHAWS, GSR-ST-6000A starter-generators and a 12SAM-25 battery were also fitted. At an early test stage, the aircraft was to be fitted with NR-30 guns, an RSIU-4 radio and a new Globus ILS receiver, but this was never done.

The capacity of the oxygen system was increased to 10 litres (2.2 Imp gal), or five spherical 2-litre (0.44-Imp gal) bottles. A pitot boom was installed on each wingtip, with the flight instruments connected to the starboard pitot and the other avionics to the port one.

The first prototype, designated SM-7/1 and powered by two AM-9Bs (RD-9Bs) rated at 31.87 kN (7,164 lb st) in full afterburner, was completed in July 1954. It entered flight test almost simultaneously with the SM-9/1; V. A. Nefyodov made the first flight on 28 August. By the time the test programme was completed on 15 December, the aircraft had logged 25 hours 36 minutes in 43 flights. After that the SM-7/1 was transferred to NII VVS for state acceptance trials; the AM-9B engines were tested along with the interceptor itself.

Developed in parallel with the SM-9 day fighter, the SM-7/1 was the first of the radar-equipped all-weather fighters which culminated in the MiG-19P production series.

The second and third prototypes, SM-7/2 and SM-7/3, identical in equipment to the first aircraft but incorporating revisions in the manner of the SM-9/2 and SM-9/3, were built in late 1954. Since the fighter and interceptor versions were developed concurrently, all the shortcomings of the SM-9/1 were present on the SM-7/1. Hence, the changes introduced on the second and third interceptor prototypes were identical to those of the second and third fighter prototypes. The most important change was the introduction of slab stabilisers with BU-14 actuators. A ventral airbrake with an area of 0.45 m² (4.8 sq ft) was added, pylons protruding beyond the wing leading edge with Model 369-Sh cradles were fitted between the main gear units and 'wet' hardpoints, and the FKP-2

gun camera was replaced by an SSh-45 model.

After a brief factory test programme the second and third prototypes were also handed over for state acceptance trials. Test pilot A. G. Solodovnikov made 71 test flight in the interceptors. "Like the other aircraft, the SM-7 had a whole bunch of bugs," he recalled. "Flight test progress was slow, as the programme was frequently interrupted for modifications to be made. In late March 1955, in the very first flight of the acceptance trials programme, one of the engines 'died' at 10000 m (32,808 ft) when the aircraft was climbing in full afterburner, followed seconds later by the other engine. Attempts to relight them were not successful until the aircraft was at 6000 m and change [approx. 20,000 ft], and then only partially. To give credit where credit is due, the aircraft flew well and could even climb on one engine. The other engine fired up as I was coming in to land.

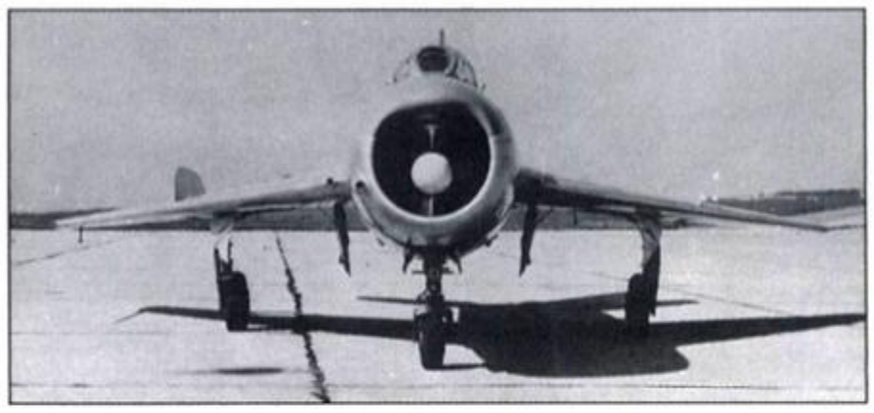
"In another flight at Chkalovskaya air base, the brake chute deployed uncommandedly and the actuators failed on one nozzle. A major shortcoming of the engines was their habit of getting stuck at intermediate rpm (between idle and full military power) when accelerated or throttled back. While this was not too critical at high altitude (the engines could be 'unstuck' by moving the throttles very slowly), getting a case of 'stuck engines' at take-off could mean big trouble."

Normally the stabilators were hydraulically controlled but a backup electric actuator was also provided. Nobody paid much attention to it until one day the control stick jammed when Georgi T. Beregovoy was flying the aircraft.

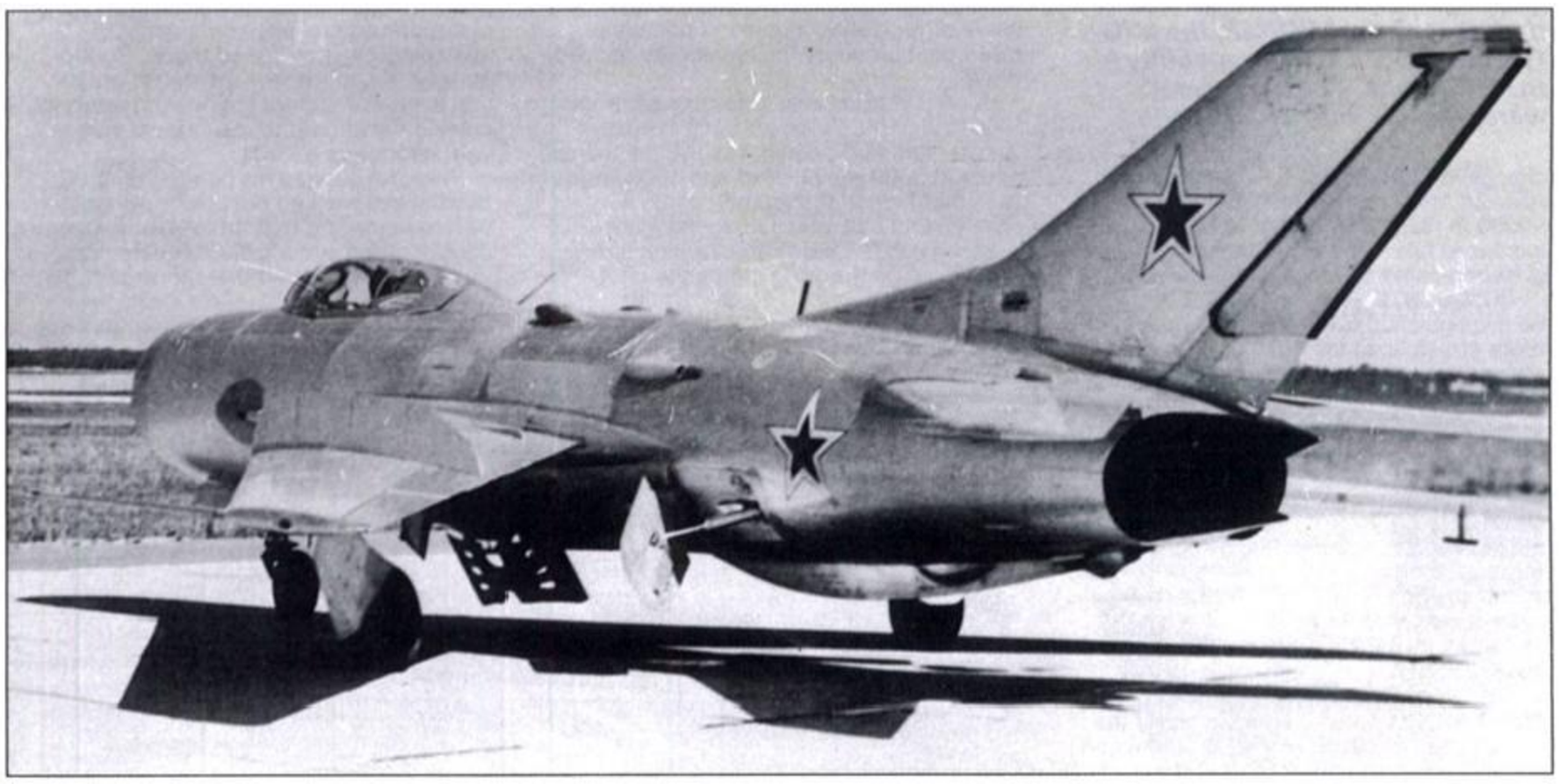
"When the pilot reported the malfunction," Solodovnikov recalled, "the ATC officer ordered him to fly the aircraft to a safe area and eject – that's what the backup stabilator actuator is for. However, Beregovoy reported that he had enough fuel for another 30 or 40 minutes and would try to land using the backup actuator. Some 20 minutes later he reported that he could take the aircraft down to 5-6 m (16-20 ft) above the ground and requested permission to land.

"The approach was very flat. The most critical moment was when Beregovoy was down to 20 m (65 ft); the slightest error would cause the aircraft to either climb sharply or dive into the ground. He started to get the nose up slowly when the aircraft was less than 10 m (32 ft) above the ground and landed softly. He managed to get the aircraft back in one piece thanks to his self-control and excellent piloting skill. Even the slightest error would have been fatal because the backup actuator works rather slowly."

During the state acceptance trials the SM-7 was also flown by NII VVS pilots V. G. Ivanov, N. P. Zakharov and S. A. Mikoyan. Deputy general designer A. G. Broonov, project engineers V. A. Arkhipov, Yu. A. Korolyov and A. N. Soshin, and team chiefs Gleb Ye. Lozino-Lozinskiy, Rostislav A. Belyakov, K. N. Rozanov, A. A. Nefyodov, Yakov I. Seletskiy and N. I. Andrianov were actively involved with the SM-7 and SM-9.



Two views of the SM-7/1 prototype show the RP-1 radar installation in the nose, with the AR-18-16 transmitter in the intake centrebody and AR-18-1 receiver in the intake lip radome. Noteworthy in the top view is the conventional tailplane/elevator which was replaced by an all-moving slab unit in subsequent aircraft.



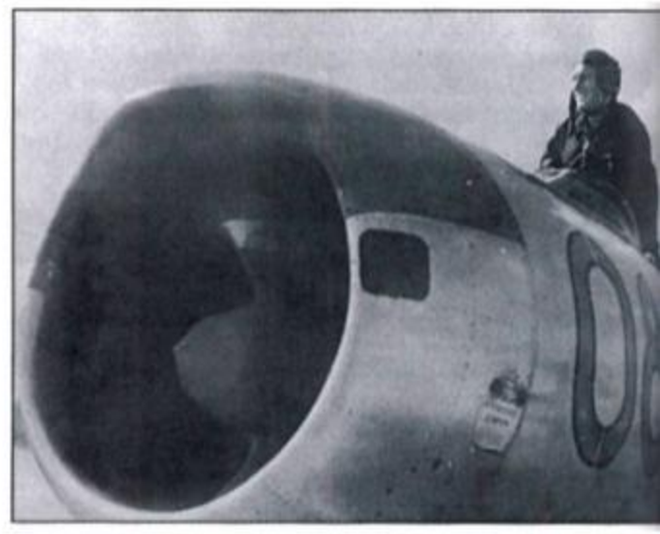
The SM-7/2 exhibits the revised aerodynamic features which were shared with the SM-9/2 day fighter prototype: all-moving tailplane, revised rudder, longer fin fillet and third airbrake added under the central fuselage.

MiG-19P (*izdeliye* 62)

Upon completion of the state acceptance trials, the SM-7 entered production at the Gorky plant in 1955 as the MiG-19P or *izdeliye* 62. It differed from the production MiG-19S mainly in having an RP-1 radar with track-while-scan capability, a new and longer forward fuselage up to frame no. 12 and a consequently relocated nose gear unit, increasing wheelbase to 4.45 m (14 ft 7 in). Other changes included the absence of the fuselage-mounted gun, a pitot tube relocated to the starboard wing and the gun camera relocated to starboard, changes to the electrics, pneumatic and oxygen systems, a new instrument panel layout, relocated avionics and a wider cockpit with a modified canopy featuring alcohol de-icing.

The ARU-2V automatic flight control governor which adjusted control surface deflection (depending on airspeed and altitude) made for accurate sighting at up to 15000 m (49,212 ft) but necessitated a

This MiG-19P is on display in the Kubinka museum.



Although performance was less than that of the MiG-19S, the MiG-19P introduced a new capability for the PVO units. The early radars were plagued with problems.

change in aileron mass balancing. The ARU-2A fitted to the MiG-19S had a limit of 10000 m (32,808 ft). Because of the increased take-off weight, smaller 540-litre (119-Imp gal) drop tanks had to be used.

Outwardly, production MiG-19Ps could be distinguished from the prototypes by the more streamlined fairing of the AR-18-16 transmitter aerial in the centre of the air intake. On late production aircraft, the RP-1 (Izumrood-1) radar was replaced by the RP-5 (Izumrood-2) which had an azimuth scan of about 60°, an elevation scan of +26°/-14° and a detection range of 12 km (7.45 miles). Other differences from the MiG-19S were the absence of a rudder trim tab (though this was later introduced) and fewer cooling air intakes on the aft fuselage. The bulky radar screen with its sunblind somewhat restricted the pilot's view, and the longer nose did not help this either.

The MiG-19P could be armed with two RO-57-8 (ORO-57K) FFAR pods under the wings. The NR-23 guns of early production aircraft were soon replaced by heavier NR-30s.

The MiG-19P served not only with the Air Defence Command (PVO) but with the air force (VVS) and naval air arm (AV-MF). It was slightly inferior in performance to the MiG-19S, having a top speed of 1432 km/h (889 mph), a service ceiling of 17250 m (56,594 ft) and the ability to climb to 10000 m (32,808 ft) in 1.2 minutes. Maximum range with drop tanks did not exceed 1520 km (944 miles).

Though the MiG-19P was a major boost to the PVO's intercept capability, it suffered from a whole range of new defects which were unknown to the MiG-19S – mostly numerous radar malfunctions. The relocation of the pitot boom from under the nose to the starboard wingtip also led to its share of problems, as ground personnel often got burned by the electrically de-iced pitot.

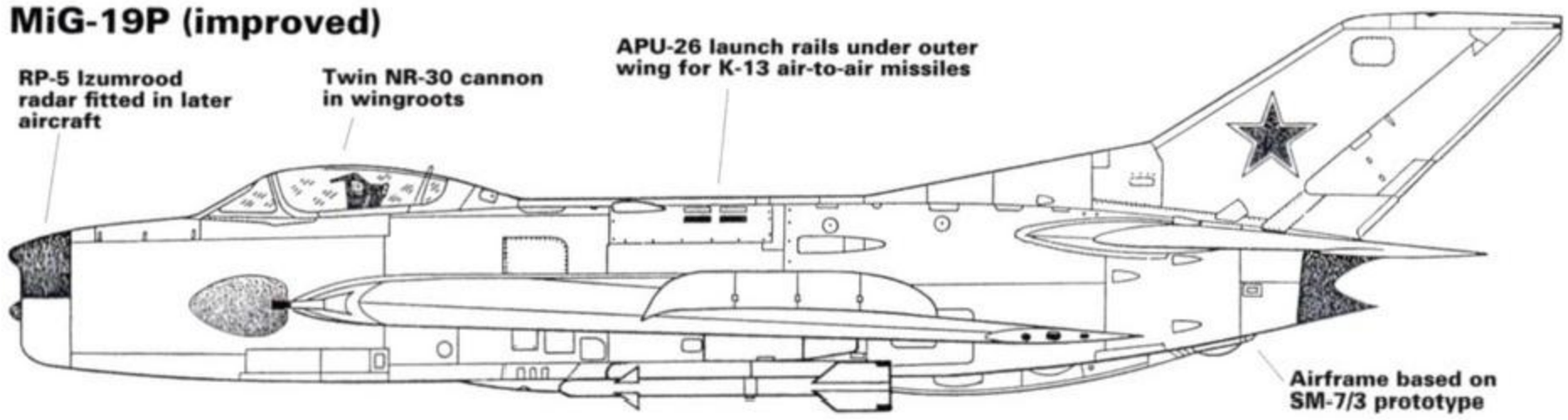
A very unusual incident occurred in Poland in 1959. Polish air force Poruczyk (Lieutenant) R. Operacz was flying a training sortie at 3000 m (9,842 ft) and 1000 km/h (621 mph) when the starboard gun's ammunition belt snapped during a sharp manoeuvre. The loose ammunition sliding around inside the wing struck the pitot attachment and short-circuited the automatic control adjuster's sensor, switching it to low-speed mode. Control surface deflection was increased greatly, and even the slightest stick and pedal inputs caused the aircraft to manoeuvre violently with enormous *g* loads.

The pilot banged his head against the canopy and blacked out briefly several times before managing to throttle back and regain control of the aircraft. Subsequent investigation showed that the aircraft, which was stressed for +8*g*, had been subjected to loads between +10*g* and -5*g* – and still stayed in one piece.

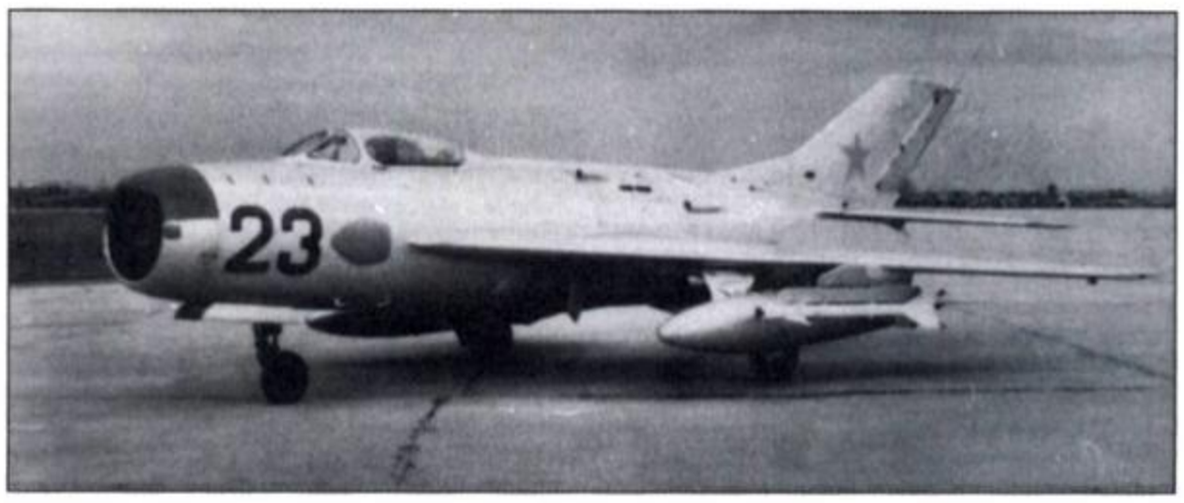
The MiG-19P was codenamed 'Farmer-B' by NATO.

Production MiG-19Ps had a more streamlined centrebody radome compared to that of the SM-7 prototypes. Late production aircraft had the more capable RP-5 radar.

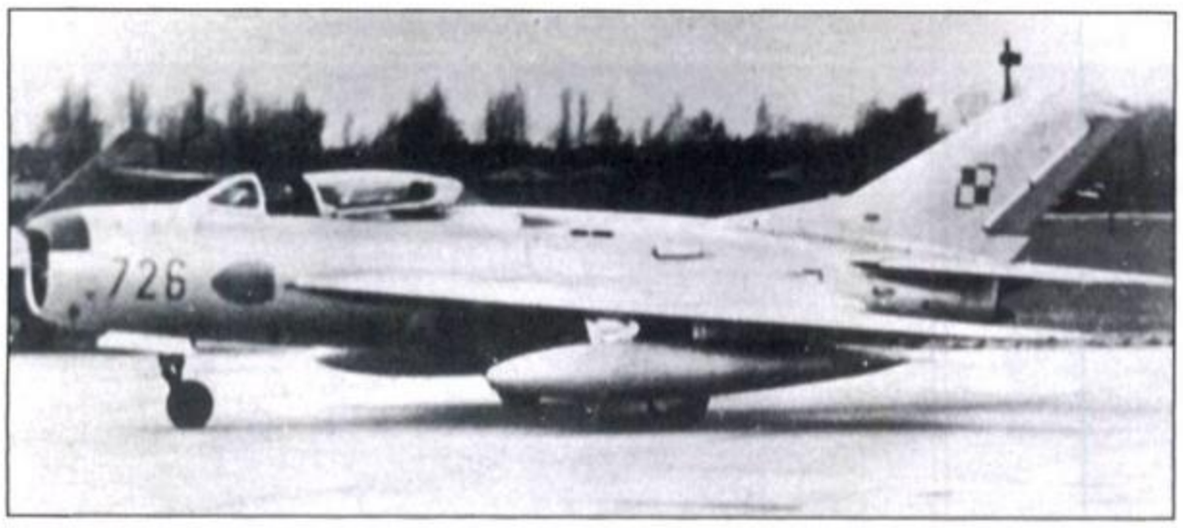
MiG-19P (improved)


RP-5 Izumrood radar fitted in later aircraft
Twin NR-30 cannon in wingroots
APU-26 launch rails under outer wing for K-13 air-to-air missiles
Airframe based on SM-7/3 prototype

Right: Later in their careers many MiG-19Ps were modified to carry the K-13 missile on newly-fitted outboard launchers. This aircraft has had its cannon removed. The ORO-57K rocket pod remained an important weapon of the radar fighter, augmenting the twin NR-30 wingroot cannon.



Below and below right: MiG-19Ps were supplied to several Warsaw Pact and other client states. Poland (below) and Czechoslovakia (below right) were important operators.



MiG-19P minor variants

MiG-19P with RD-9BF engines

In order to improve the MiG-19P's performance, one production aircraft was re-engined with uprated RD-9BF turbojets at a production plant.

MiG-19P with SRO-2 IFF

In 1956 a MiG-19P was experimentally fitted with an SRO-2 Khrom IFF transponder for evaluation purposes. The transponder was part of the Khrom-Nikel (Chrome-Nickel) IFF system. The evaluation was successful and the transponder was standardised for Soviet military and commercial aircraft.

MiG-19PG interceptor

In 1955 the MiG-19P was equipped with the Gorizont-1 command link system. It guided the aircraft to the target and transmitted coded speed, heading and altitude data to ground control centres via the modified RSIU-3MG Klyon UHF communications radio.

The modified aircraft were designated MiG-19PG (for Gorizont) and built on a small scale, serving with PVO units alongside standard MiG-19Ps. Later, the ground guidance system was changed and the Gorizont-1 system and associated RSIU-3MG radio deleted (the latter was replaced by an RSIU-4V unit).

SM-7A project

When the K-5 (RS-1-U) AAM became available in the late 1950s, the Mikoyan OKB decided to fit it to the MiG-19P. Some time earlier Mikoyan had tested a MiG-17PF fitted experimentally with these missiles.

The project of a version of the MiG-19P armed with four RS-1-U AAMs and designated SM-7A dated back to 1954. The standard RP-1 Izumrood-1 radar was to be replaced by the RP-5 Izumrood-2 linked to the ASP-5NV optical sight. The missiles were to be carried on APU-3 pylons with Model 369-Sh shackles. An SSh-45 gun camera was to be provided for confirming the 'kill' and another gun camera (AKS-3) for filming the missile's trajectory; in addition,

two S-13-300 high-speed still cameras were to capture the missile separation sequence. The guns were to be removed.

Eventually, however, it was decided not to go ahead with the K-5 missile system because the design bureau under P. D. Grooshin was working on the improved K-5M (RS-2-U).

SM-7M project

On 7 January 1956, Artyom I. Mikoyan approved the project of a new version of the MiG-19P interceptor designated SM-7M (M = *modifitseerovannyy* – modified). It lacked guns and was armed with four RS-2-U (K-5M) AAMs on APU-4 pylons, with appropriate changes to the wing structure. The RP-5 Izumrood-2 radar was replaced by the RP-2U – a modification of the RP-1 Izumrood-1 having a tracking range of 3500-4000 m (1,066-1,219 ft) – linked to the ASP-5N-VU optical sight. The radar detected targets and gave information on target heading and range, enabling the pilot to come within missile launch range and get the target into the optical sight. It also sent coded signals in the main channel for threat classification jointly with the IFF equipment. Like its predecessor, the RP-2U had an azimuth scan of about 60° and an elevation scan of +26°/-14°. As the target came within tracking range, information on range, bearing and elevation was automatically fed into the optical sight regardless of visibility conditions.

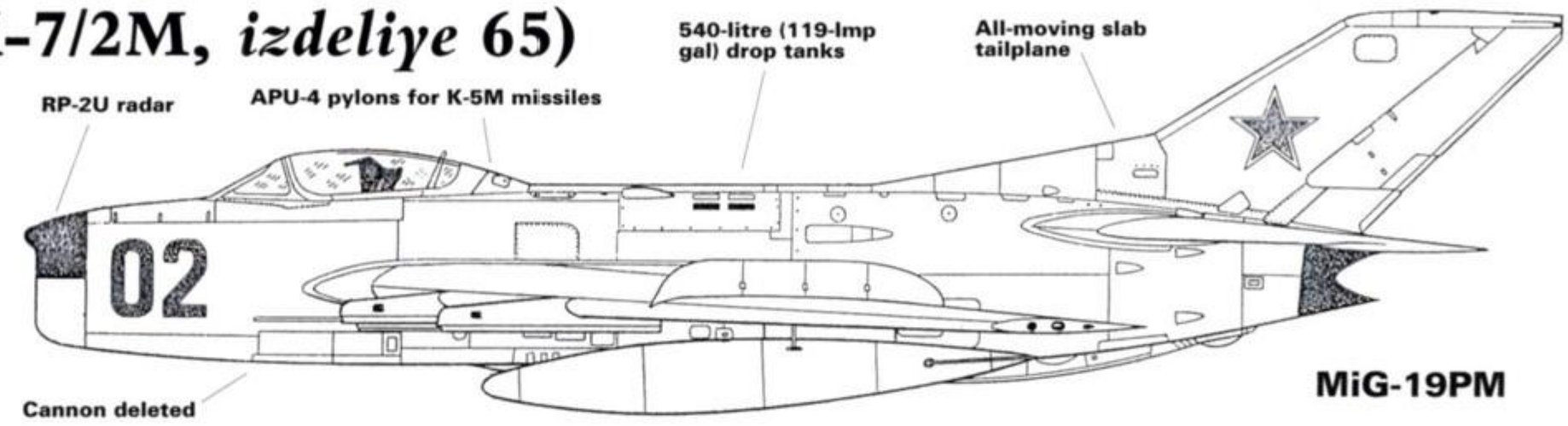
The RS-2-U (K-5M) was an improved version of the RS-1-U (K-5) with better performance (including ceiling) and kill capability. It was part of the S-2-U weapons system designed to replace the S-1-U weapons system. The missile had a 13-kg (28-lb) high explosive warhead, a launch weight of 84 kg (185 lb), a top speed of 1650 km/h (1,024 mph), and semi-active radar homing. Like the RS-1-U, the missiles could be fired singly, in pairs or all together with a couple of seconds between each. However, the RS-2-U was rather sluggish and thus could be considered a serious threat only for equally sluggish heavy bombers. What is more, the missile's maximum range (6 km/3.72 miles) exceeded the tracking range of the Izumrood radar. Still, the OKB decided to fit the S-2-U weapons system to the MiG-19P.

MiG-19PM (SM-7/2M, *izdeliye* 65)

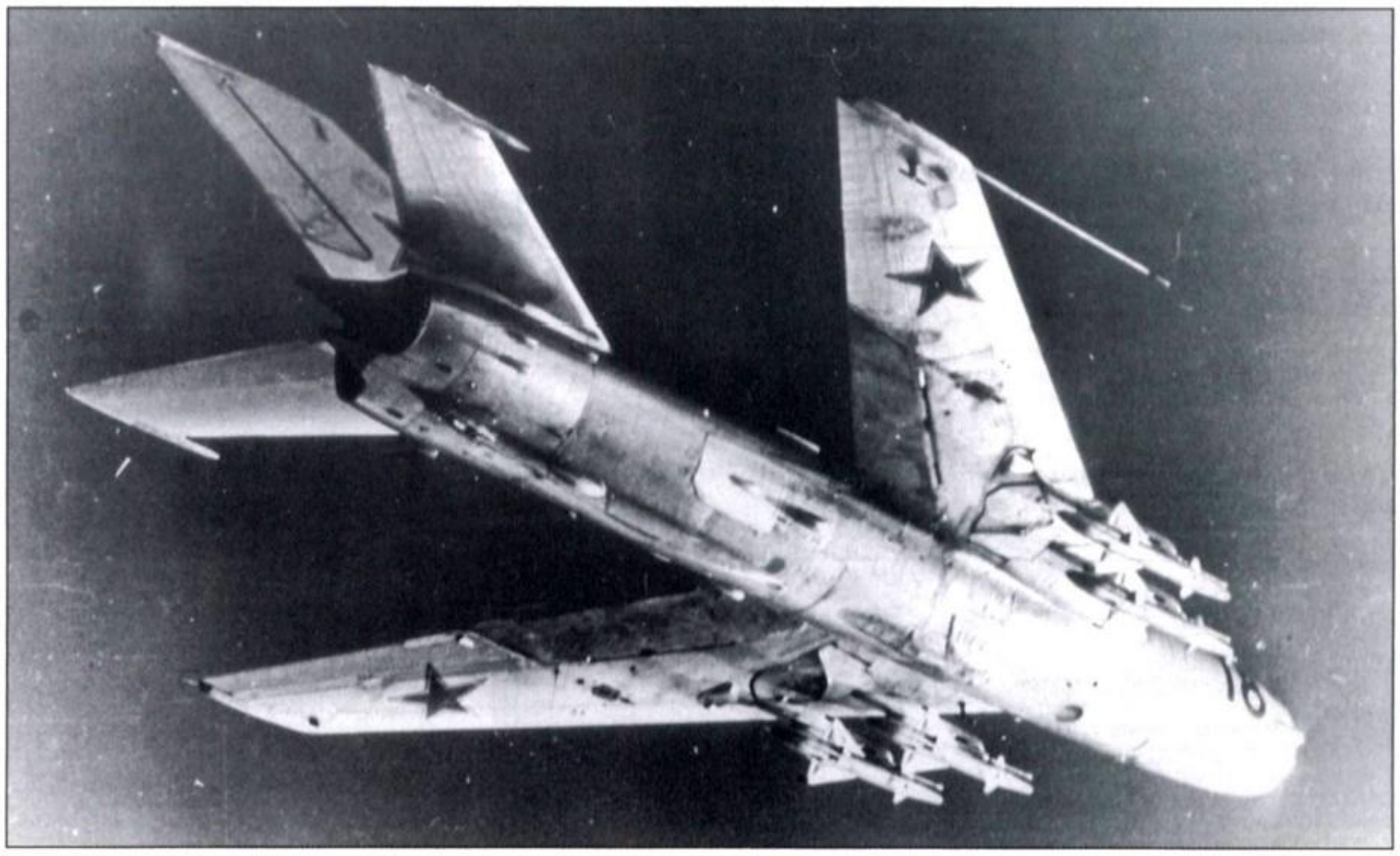
In January 1956 the first prototype MiG-19P (SM-7/1) was fitted with the K-5M missile system and entered trials as the SM-7/1M. Soon afterwards the second prototype, SM-7/2, was similarly converted and became the SM-7/2M; unlike the first prototype, it featured slab stabilisers.

Upon completion of factory tests the SM-7/2M was transferred to NII VVS for state acceptance trials which lasted a full year – from 14 October 1956 through 23 October 1957. Test pilot S. A. Mikoyan performed most of the flights at NII VVS. The trials were successful and the aircraft was cleared for production. The Mikoyan OKB handed over the drawings to the Gorky plant in 1957 and the SM-7/2M entered production as the MiG-19PM or *izdeliye* 65; some 250 were built.

The MiG-19PM differed from the MiG-19P in having a longer fin fillet, as in the MiG-19S, a rudder with a trim tab, slab stabilisers and no provision for FFAR pods. Despite the lack of gun armament, early production MiG-19PMs had gun blast plates on the fuselage at the wingroots – a leftover from MiG-19P days. Other differences



MiG-19PM

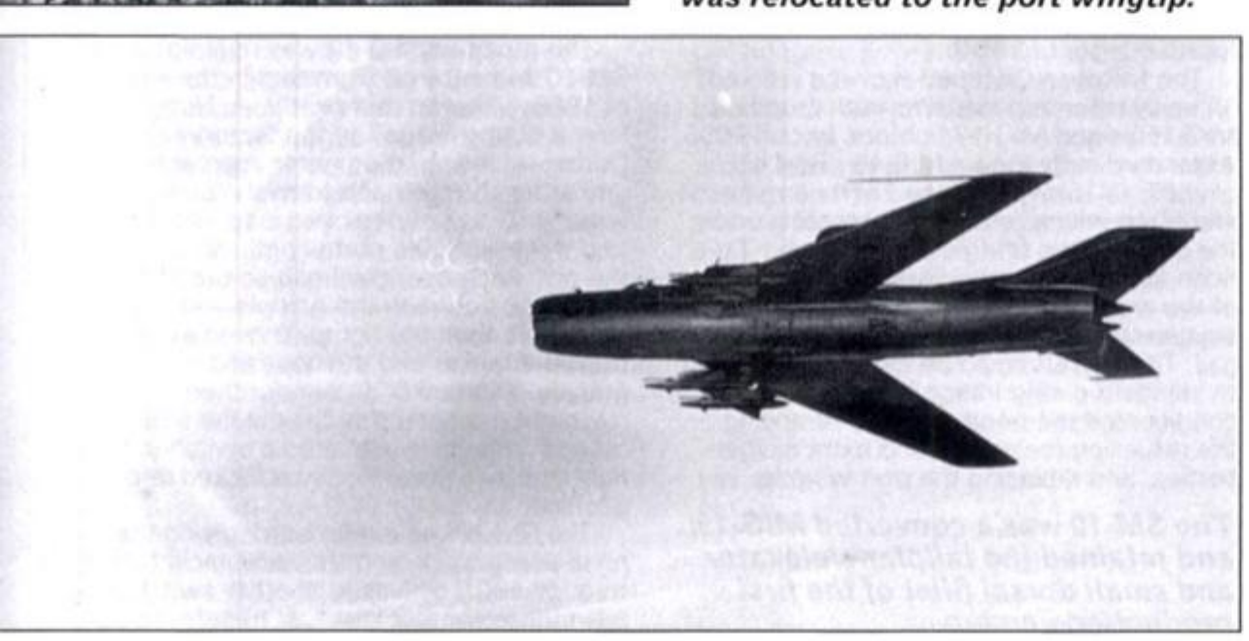


Left: This view shows the K-5M (RS-2-U) missiles on their launch rails. The 84-kg (185-lb) radar-guided beam-riding weapon was known to NATO as the AA-1 'Alkali'.

Below: The MiG-19PM's main pitot was relocated to the port wingtip.

Above: The MiG-19PM represented the first generation of Soviet missile-armed interceptors. Serviceability, especially of the radar, was very poor.

Below: This MiG-19PM, complete with its four K-5M missiles, is on display at Monino. The intake cover hides the centrebody transmitter radome.



Despite the small production run (around 250), MiG-19PMs were supplied to Warsaw Pact air forces. Illustrated are East Germany (above left), Poland (above), Czechoslovakia (left) and Hungary (below).

included a modified canopy jettisoning mechanism and no Sirena-2 RHAWS, although this was reinstated on late production aircraft.

The avionics suite was almost identical to that of the MiG-19P, except that the DGMK-3 gyro magnetic compass was replaced by a GIK-1 induction gyro magnetic compass. An emergency feature was introduced, whereby if one of the two pitot tubes failed, instrument input could be switched to the good one. The missiles were fired by a stick-mounted button, using a PUVS-52 launch mode selector.

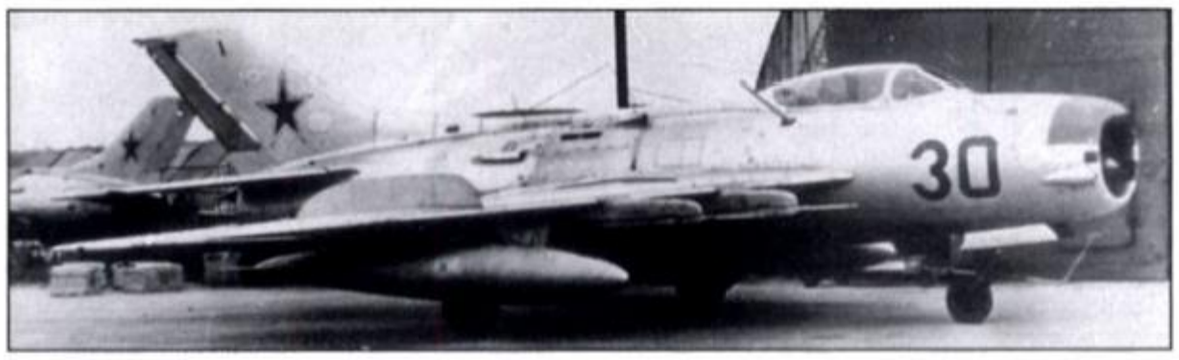
On the MiG-19PM, avionics reliability turned out to be even worse than on the MiG-19P and performance was nowhere near as good as that of the MiG-19S. Top speed had dropped from 1452 km/h (902 mph) to 1250 km/h (776 mph). This, and the frequent control system failures, certainly did not help the type's bad reputation, although reliability did improve in the closing stages of the MiG-19PM's service.

In addition to the Soviet air force, the MiG-19PM was supplied to some Warsaw Pact nations. It was codenamed 'Farmer-D' by NATO.

MiG-19PML

After being retrofitted with the Lazoor (Prussian Blue) command link system in the 1960s, MiG-19PM interceptors were redesignated MiG-19PML.

The missile-armed MiG-19PM became the PML with the addition of a command guidance link.



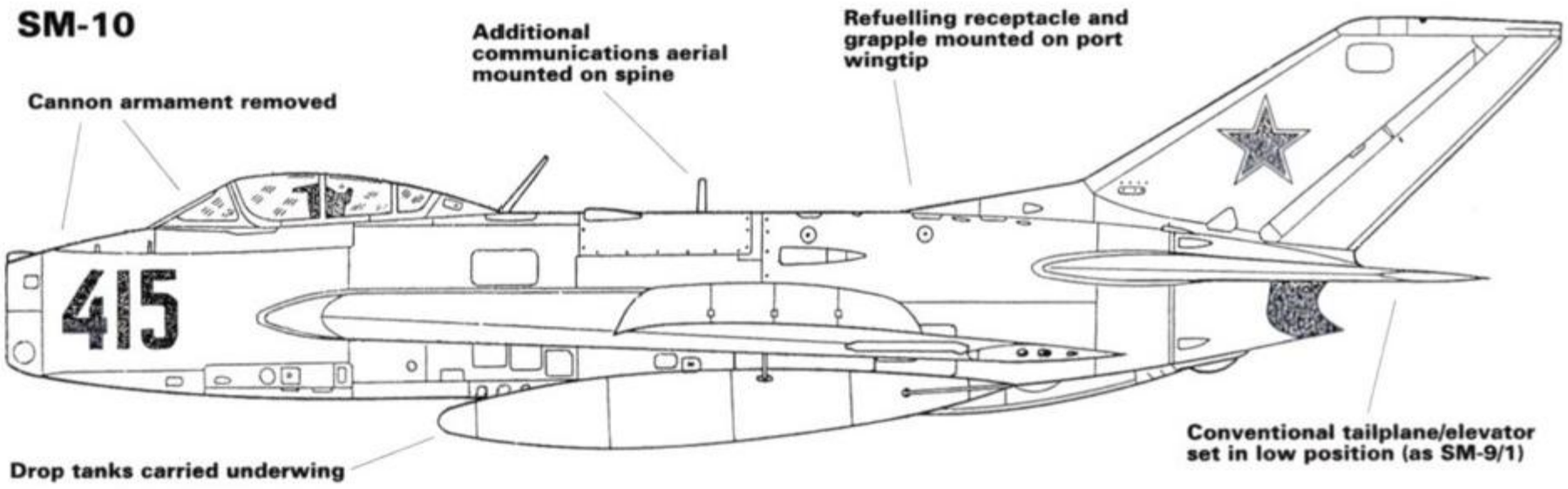
MiG-19P mod

As PVO fighter units received air-to-air missiles, a small number of early MiG-19Ps were converted to MiG-19PM at air force aircraft overhaul plants in the early 1960s. Unlike the MiG-19PM, these aircraft could only carry two RS-2-US (AA-3 'Anab') or R-3S AAMs.

SM-10

The MiG-19's range – about 2,000 km (1,242 miles) with two 760-litre (176-Imp gal) drop tanks – was insufficient for a number of missions. Therefore, even before the type entered production, the Council of Ministers issued a decree in May 1954, ordering the Mikoyan OKB to develop an aerial refuelling system and prepare an aircraft equipped with this system for state acceptance trials. Simultaneously, the Tupolev design bureau (OKB-156) was ordered to develop a tanker version of the Tu-16 'Badger' twin-jet bomber – which emerged as the Tu-16Z (Z = *zapravschchik* – tanker).

The Tupolev OKB had by then gained some experience with tankers, experimenting with Tu-2 and Tu-4 piston-engined bombers fitted with a wingtip-to-wingtip refuelling system. Design studies of a similar system for the Tu-16 began as early as in the autumn of 1953. On 17 September 1953, MAP issued Order No. 44 concerning the design of an aerial refuelling system based on the Tu-16. On 26 May the next year, the Council of Ministers issued a decree setting a deadline for the system to be submitted for state acceptance trials (the fourth quarter of 1954).


SM-10
Additional communications aerial mounted on spine
Refuelling receptacle and grapple mounted on port wingtip
Cannon armament removed
415
Drop tanks carried underwing
Conventional tailplane/elevator set in low position (as SM-9/1)

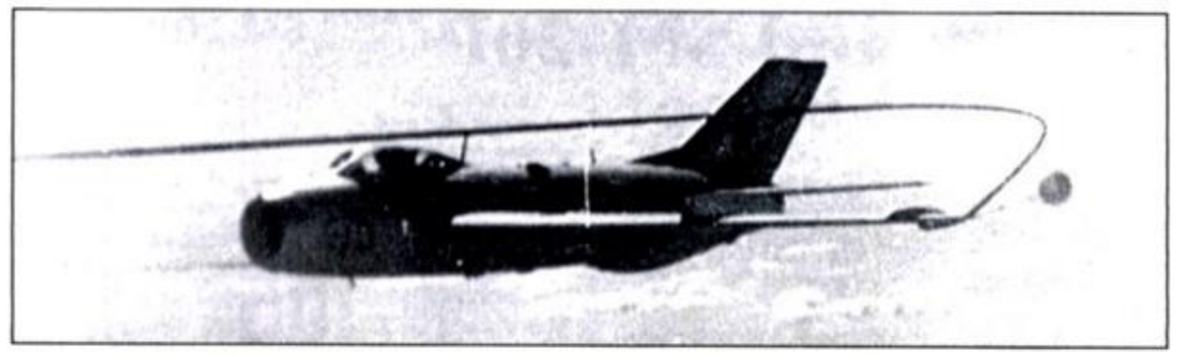
The Mikoyan OKB had likewise worked on aerial refuelling systems with modified MiG-15bis and MiG-17 fighters. In mid-1955 a standard early-model MiG-19 ('Red 415', c/n 59210415) was stripped of its armament and fitted with a refuelling receptacle under the port wingtip (the Tu-16Z deployed its hose from the starboard wingtip). Because of the greater endurance, the supply of oxygen was increased to 18 litres (4 Imp gal). The aircraft could be easily reconverted to standard configuration in service conditions if the need arose by removing the refuelling receptacle and extra oxygen bottles, and replacing the port wingtip. The tanker was standard, except for the hose diameter reduced to 50 mm (2 in).

The SM-10 was a converted MiG-19, and retained the tailplane/elevator and small dorsal fillet of the first production version.

The modified MiG-19 was redesignated SM-10 and entered flight test in the autumn of 1955; Mikoyan test pilot V. A. Nefyodov flew it during Stage I of the factory tests. During refuelling, the fighter approached the tanker trailing the hose from the starboard wingtip. The pilot deployed a special grapple under the SM-10's port wingtip and placed the port wing over the hose so that the latter was between the grapple and the drop tank; then the fighter moved away from the tanker and the hose slid into the grapple. The tanker's operator then rewound the hose slowly until the end fitting of the hose activated a switch in the fighter's receptacle and was locked into position.

The SM-10 moved forward, giving the hose some slack, and the receptacle turned through 180°, activating another switch and telling the operator that fuel transfer could

Two views show the SM-10 during wingtip-to-wingtip refuelling trials with a Tu-16Z tanker. The photo above was taken from a remote camera positioned on the Tu-16's wingtip.



begin. The tanker's powerful pumps delivered about 1000 litres (220 Imp gal) per minute, filling the fighter's tanks in about three minutes. When the tanks were full an indicator light illuminated; the fighter's pilot shut the fuel transfer valve and broke contact with the tanker.

Refuelling was possible at 450-500 km/h (279-310 mph) and 9000-10000 m (29,527-32,808 ft). The tanker's operator could terminate refuelling at any moment if necessary. Multiple refuellings were possible in a single sortie, both day and night; for night refuelling the fighter's port wingtip was illuminated by a spotlight.

The chief problem during refuelling was the tanker's wake turbulence, so in 1956 the SM-10 was transferred to LII for Stage II tests. The tanker's hose was modified so that it more securely connected with the receiver aircraft, avoiding hose folding, decreasing the effect of the Tu-16's wingtip vortex and reducing the required hose length; no changes were made to the fighter. During Stage II the SM-10 was flown by V. N. Pronyakin. Endurance with a single refuelling was six hours. At this stage the refuelling process was fully automated; the SM-10 made the rendezvous with the tanker using the Oozel IFF as a short-range navigation system.

After the completion of Stage II the aircraft passed the state acceptance trials with flying colours. Still for some obscure reason, the refuelling system was not fitted to production MiG-19s.

MiG-19 refuelling receptacle testbed

Experiments with refuelling systems continued at LII in late 1957. This time a hose-and-drogue refuelling system was envisaged and the best location of the refuelling probe had to be determined. To this end, the 10th production Gorky-built MiG-19 ('Red 10', c/n 59210110) was fitted with no fewer than four dummy refuelling probes.

Probe no. 1 was a Z-shaped tube bent at right angles and attached to the port wing gun mount so that the front end was level with the top of the canopy. The probe was located 1.4 m (4 ft 7 in) from the air intake and 0.55 m (1 ft 9.6 in) from the fuselage side, protruding 0.75 m (2 ft 5.5 in) beyond the wing leading edge.

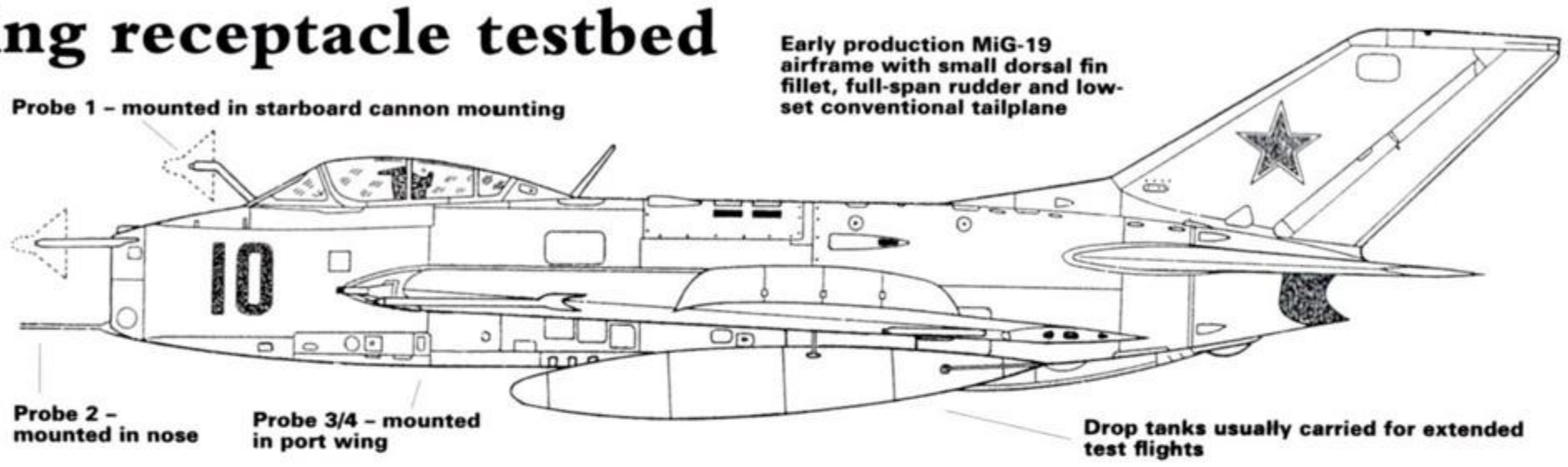
Probe no. 2 was located in the fuselage nose, offset 25 cm (10 in) to port and protruding 0.80 m (2 ft 7.5 in) beyond the intake lip.

Probes nos 3 and 4 were attached to the port wing 1.8 m (5 ft 10.9 in) and 2.62 m (8 ft 7 in) from the centreline, i.e., 1.05 m (3 ft 5.4 in) and 1.85 m (6 ft 0.9 in) from the fuselage side, respectively. Probe no. 3 protruded 2.0 m (6 ft 6.5 in) beyond the wing leading edge and was located 1.8 m (5 ft 10.9 in) from the air intake; for probe no. 4, these distances were 1.0 m (3 ft 3.4 in) and 4.0 m (13 ft 1.5 in), respectively.

The Tu-16 had by then another tanker version, the Tu-16N, equipped with the hose-and-drogue system. However, the Tu-16N prototype was unavailable, being tied up with other tests. Therefore, an Ilyushin Il-28 'Beagle' tactical bomber (c/n 2402101) was converted into a makeshift 'tanker trainer'. An experimental winch was installed in the bomb bay, paying out a 5-mm steel cable with a drogue of 0.64 m (2 ft 1 in) diameter to a point 42 m (137 ft) beyond the bomber's tail.

The test programme was supervised by project engineer N. N. Koormyatskiy. Initially, a 36-kg (79-lb) drogue without a stabilising device was used; after the first four flights, however, it was replaced with a stabilised drogue. Both models had a lock for making contact with the probe.

The MiG-19 would 'hit the tanker' at 7000 m (22,965 ft) and 450-470 km/h (250-261 kt) IAS, approaching from a stand-by position 10-20 m (32-65 ft) behind the drogue. Contact was usually made in a climb, with or without sideslip. Approach speed varied from 0.3 to 12 m (1-39 ft) per second or 1-30 km/h (0.5-16.6 kt) IAS. After making contact, the MiG-19 remained locked into the drogue for three to five seconds, then slowed down and broke away. For safety's sake, the drogue lock was set at an unlocking force of 60-80 kg (132-176 lb). The fighter usually carried drop tanks to increase mission time.


Probe 1 – mounted in starboard cannon mounting
Early production MiG-19 airframe with small dorsal fin fillet, full-span rudder and low-set conventional tailplane
10
Probe 2 – mounted in nose
Probe 3/4 – mounted in port wing
Drop tanks usually carried for extended test flights

A total of 10 flights was made by test pilots (1st class) S. F. Mashkovskiy, P. I. Kaz'minutes and S. N. Anokhin. These pilots were familiar with aerial refuelling techniques, having taken on fuel from a Tu-4 tanker in the modified MiG-15bis fighters.

On 28 August 1957, the Il-28 'tanker trainer' made a test flight to check the winch. The drogue was deployed at 7000 m (22,965 ft) and 400, 450, 500 and 550 km/h (222, 250, 277 and 305 kt) IAS. The actual 'refuelling' flights are detailed in the table.

The 10th flight had to be terminated when the drogue entered the fighter's air intake and disintegrated. The debris damaged one of the engines.

The tests showed that making contact with the tanker depended mainly on the stability of the drogue, which left much to be desired – the drogue swayed crazily in the slipstream. The nose probe allowed the pilot to make contact relatively easily, providing approach speed was 0.3-0.5 m (1-1.6 ft) per second. Making contact with the other probes was difficult if approach speed was less than 2 m (6.5 ft) per second and was largely a matter of chance, as the drogue swayed 2-3 m (6.5-10 ft) from side to side. The odds were better if the fighter approached at 7-12 m (23-39 ft) per second with sideslip, but this called for considerable flying skills. The tests were only preliminary, since the drogue was attached to a cable and would probably behave differently when attached to a less flexible hose.

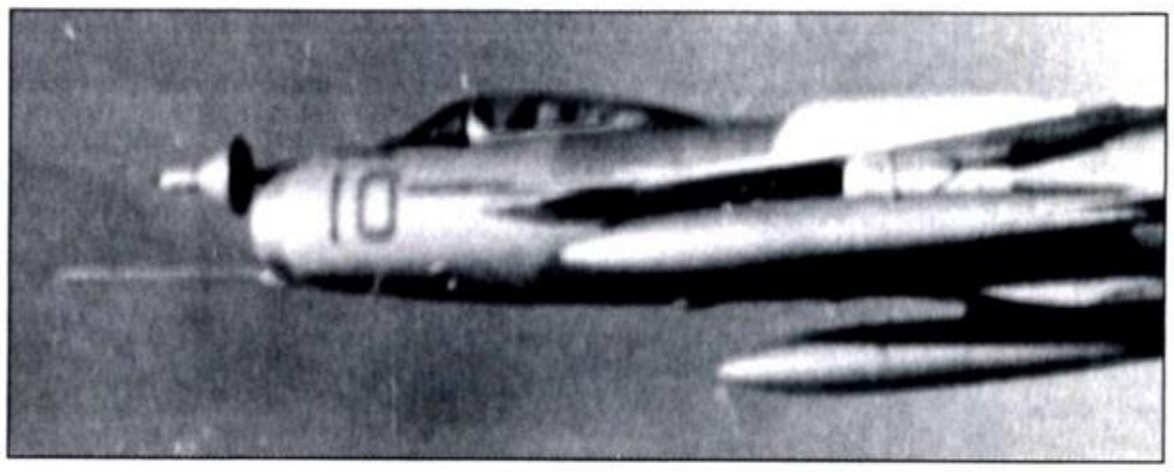
Kaz'minutes reported that "making contact with the wing-mounted probes is difficult and impracticable because of the considerable asymmetry and wing sweep. The pilot has to look sideways and backwards, which is difficult and dangerous.

"Making contact with the nose-mounted probe is easier on the MiG-15, which makes contact on the first try after two or three training flights, with an approach speed of 4-6 km/h (2.5-3.7 mph). On the MiG-19, drogue deflection is greater; so is the approach speed – 6-8 km/h (3.7-5 mph) or 1.5-2 m (5-6.5 ft) per second.

"The MiG-15's engine is less sensitive to turbulence. On the MiG-19, missing the drogue can cause the latter to be ingested by the engines and disintegrate, which is exactly what happened on the 10th flight. The MiG-19 is less responsive to stick inputs; when using the side probe [no. 1] the drogue is deflected by the shock wave generated by the fuselage."

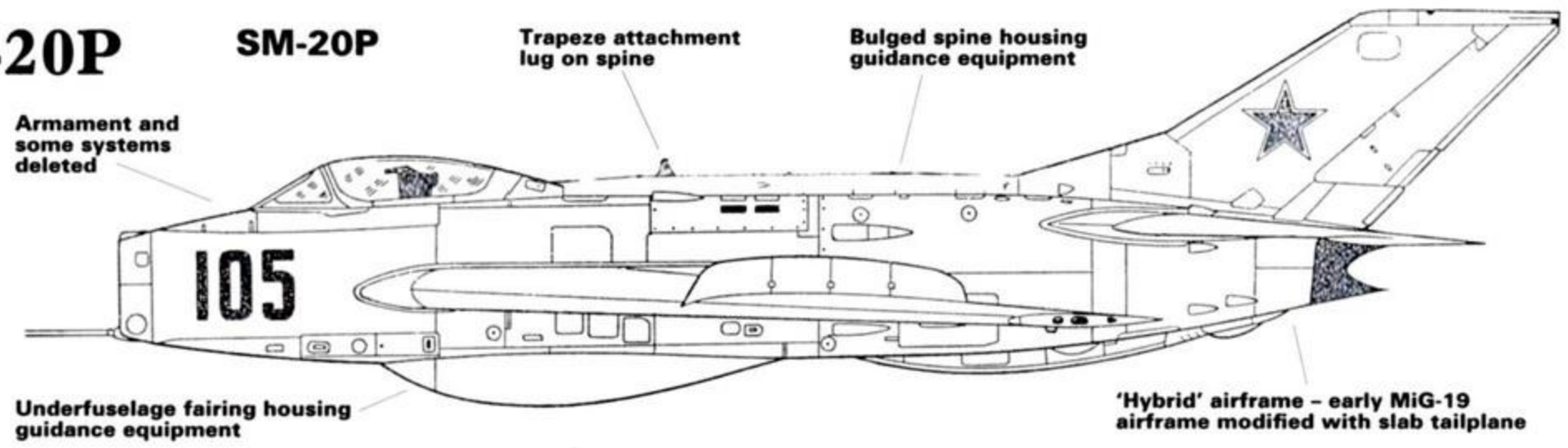
By late 1956 it became clear that introducing aerial refuelling capability was a priority for long-range bombers rather than for fighters. Besides, the Mikoyan OKB was already working on new-generation fighters which would greatly outperform the MiG-19. Therefore, the idea of giving the MiG-19 any form of aerial refuelling capability was abandoned.

Flight no.	Date	Pilot	Probes used	Successful attempts/total attempts
1	18 Sep 1957	Mashkovskiy	all	2 of 4 (nose probe)
2	20 Sep 1957	Mashkovskiy	nos 1, 2, 3	2 of 7 (nose probe)
3	24 Sep 1957	Mashkovskiy	nos 1, 2, 3	2 of 5 (nose probe)
4	27 Sep 1957	Mashkovskiy	no. 3	no contact
5	3 Oct 1957	Mashkovskiy	no. 4	1 of 33
6	16 Oct 1957	Anokhin	No. 3	2 of 41
7	30 Oct 1957	Mashkovskiy	no. 3	1 of 12
8	1 Nov 1957	Mashkovskiy	no. 1	2 of 34
9	7 Dec 1957	Kaz'minutes	no. 1	9 of 30
10	27 Dec 1957	Kaz'minutes	nos 1, 2	no contact (accident)



Two views show the early MiG-19 engaged in probe and drogue refuelling trials. The 'tanker' was an Il-28 trailing a dummy drogue on a length of cable.

SM-20 and SM-20P


SM-20P
Trapeze attachment lug on spine
Bulged spine housing guidance equipment
Armament and some systems deleted
105
Underfuselage fairing housing guidance equipment
'Hybrid' airframe – early MiG-19 airframe modified with slab tailplane

In the mid-1950s the Soviet Union began a massive design effort aimed at creating air-launched cruise missile systems. New bombers and stand-off missiles were developed in parallel. One of these missiles was the turbojet-powered Kh-20 (AS-3 'Kangaroo') developed as part of the K-20 weapons system (K = *kompleks [vo'orouzheniya]* – weapons system) which also included the Tu-95K-20 'Bear-B' bomber. The Kh-20 was based on the MiG-19's airframe and developed by the Mikoyan bureau's Section K headed by Mikhail I. Gurevich.

To verify the missile's guidance system, two early-production MiG-19s were converted into testbeds (perhaps it would be more accurate to call them missile simulators). The first aircraft, designated SM-20 or SM-20/1 and wearing no tactical code, was remote-controlled; the second ('Red 105', c/n probably 59210105) was a manned version, hence the designation SM-20P (P = *peeloteerooyemyy* – flown by a pilot) or SM-20/2.

The aircraft were lightened by removing the armament, radio, IFF, gun ranging radar, MRP-48 marker beacon receiver, RV-2 radio altimeter, Sirena-2 RHAWS and NI-50IM navigation display. Both aircraft were fitted with the YaK autopilot; the SM-20P could be controlled both by the pilot and the autopilot. The separate stabilisers and elevators were replaced by slab stabilisers as in the MiG-19S, but the early-model vertical tail was retained, albeit that the dielectric fin cap was slightly modified. A prominent square-section fuselage spine was added between the canopy and fin fillet, with a hefty lug for the mother ship's trapeze amidships. Other non-standard features were a large teardrop fairing aft of the nose gear unit, containing the guidance system or possibly test instrumentation, and a downward-pointing whip aerial on the starboard side of the nose.

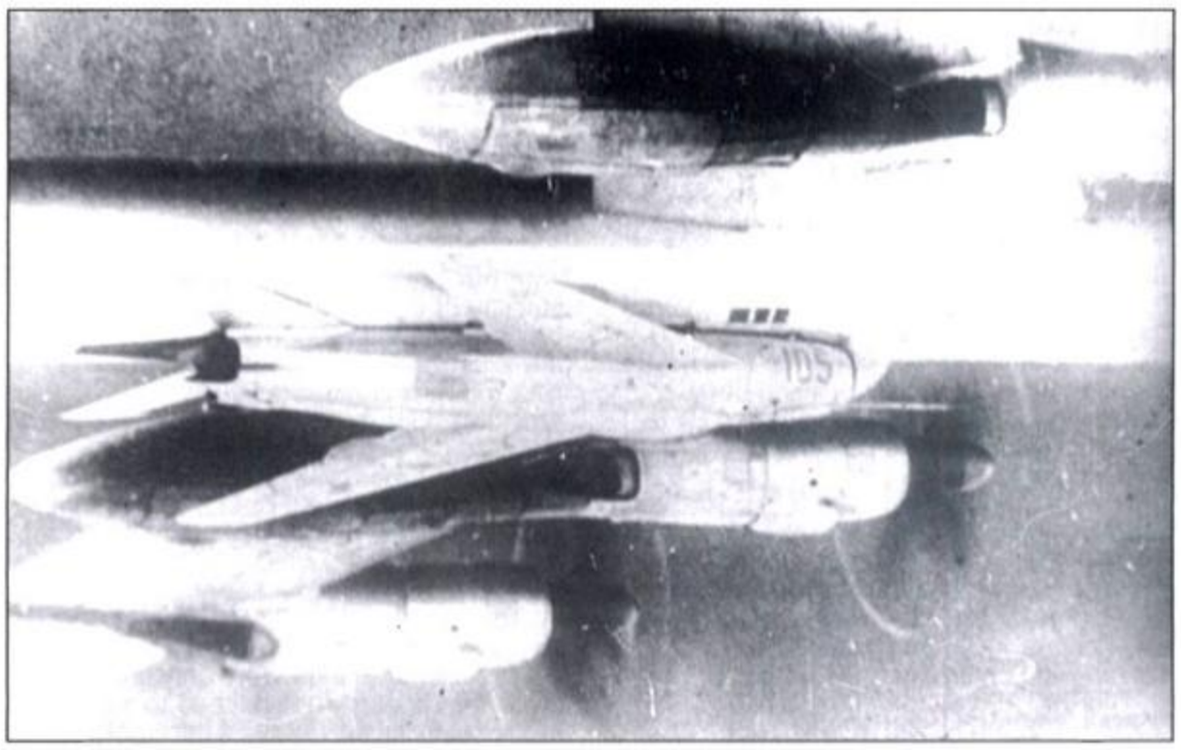
The Tu-95K prototype, a converted early-model Tu-95 bomber, served as the mother ship. It was equipped with a YaR target illumination radar replacing the original glazed nose; the radome was wider than the bomber's fuselage, resulting in a characteristic 'duck bill'. The bomb bay was modified with a special cut-out at the rear to accommodate the fighter's fin; the doors were deleted and small windows added to admit some light into the bay when the SM-20 was semi-recessed in the fuselage. A retractable fairing was incorporated immediately forward of the bomb bay to prevent the fighter's engines from windmilling during cruise. (This was retained on production Tu-95K-20s but the missile bay was reconfigured and closed by doors when empty.) Ciné cameras were installed in three teardrop fairings under the inner wings and the starboard wingtip to capture the separation sequence.

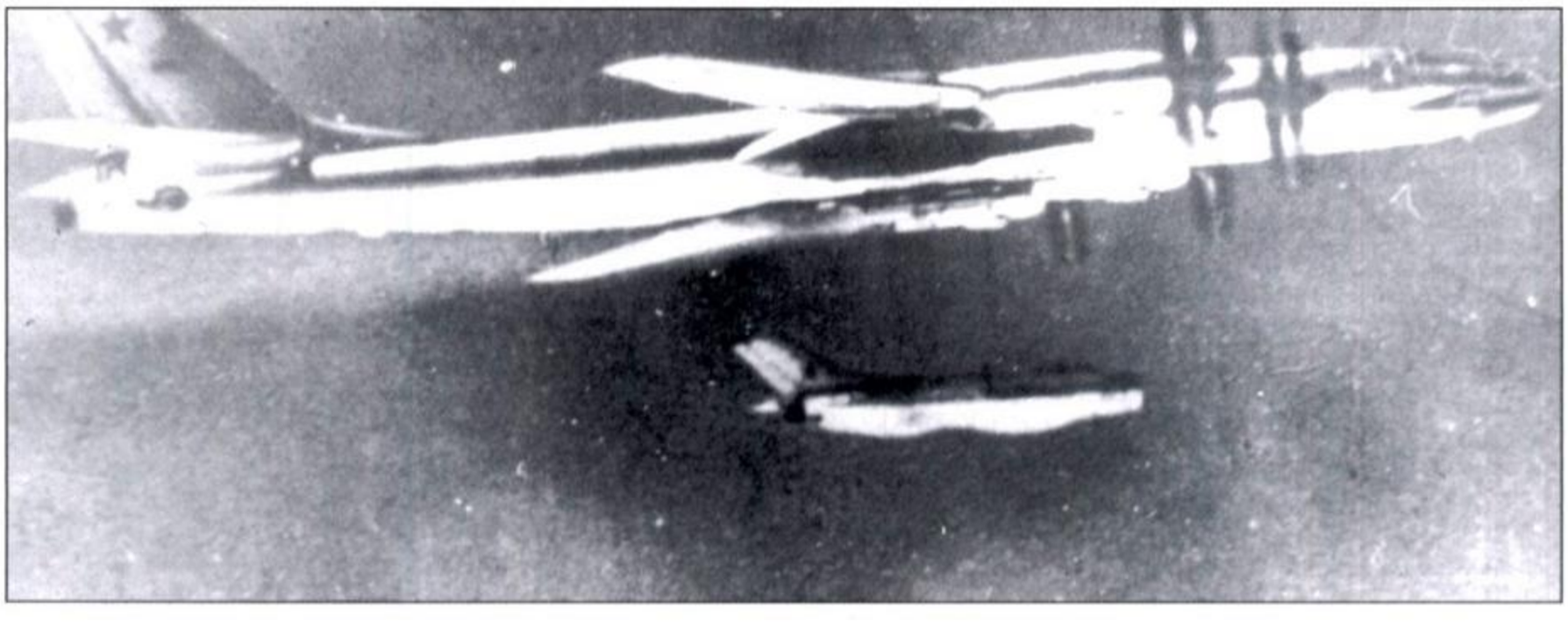
This is the pilotless SM-20, seen dropping away from the Tu-95K. Just visible beneath the bomber's engine nacelle is the suspension beam of the trapeze, while the SM-20 displays the additional radio aerial under the nose.

Conversion of the SM-20/1 was completed in 1956, and tests began the same year. The second aircraft joined the test programme in 1957; it was flown by LII test pilot Amet-Khan Sultan and V. G. Pavlov of the Ministry of Radio Industry's Research Institute. A. I. Vyooshkov was the programme's project engineer.

The SM-20P was used to test the Kh-20's guidance system at the final stage of the trajectory. It was suspended under the Tu-95N with the pilot sitting in the cockpit. The engines were not started until the mother ship's pilot gave the command by intercom when the altitude was right. After disengagement, the fighter's pilot directed the aircraft towards the target 'painted' by the Tu-95's powerful radar and monitored the operation of the guidance system. When the system got a lock-on, the pilot switched it off and flew the aircraft manually, landing at the home base in the usual way.

Some difficulties were experienced with engine starting at high altitude. Therefore, the SM-20P was fitted with modified engines featuring a carburetted ignition system. After successful completion of the initial test phase, the guidance system was removed from the simulator aircraft and fitted to the prototypes of the real thing – the Kh-20 missile.





Above: 'Red 105' was the piloted Kh-20 test vehicle and lacked the undernose antenna. The aircraft was suspended by a single lug.

Above right: The SM-20P was carried in the Tu-95K's bomb bay which was modified to accommodate the fin. Small windows were incorporated into the fuselage side to provide the SM-20P's pilot with some ambient light prior to launch.

Right: The SM-20P launches from the Tu-95K. The bomber provided guidance inputs to the fighter's YaK autopilot using its YaR radar. The pilot monitored the guidance system before taking over for the landing.

SM-K/1 and SM-K/2

In 1957 the Mikoyan OKB converted another two aircraft – this time late-model MiG-19S fighters – into cruise missile simulator aircraft designated SM-K/1 and SM-K/2, respectively. They were used to test the guidance system of the turbojet-powered K-10S (AS-2 'Kipper') anti-shipping cruise missile developed for the Tu-16K-10 'Badger-C' naval missile carrier.

The SM-K/1 and SM-K/2 were fitted with the YeS guidance system working with the Tu-16's YeN target illumination radar (the second letter indicates where the component is installed: S = *snaryad* – missile; N = *noseetel* – carrier). The system comprised the YeS-2 mid-range guidance receiver, the YeS-1 terminal guidance (homing) unit and the YeS-3 autopilot. Test instrumentation was also fitted. To make room for all this, the guns, ASP-5N gunsight, radio, RHAWS, marker beacon receiver, radio altimeter, gun camera and fuel cell no. 2 had to be removed. The hydraulics and electric system were modified.

Part of the guidance system was carried in the fuselage and the wing gun bays; the remainder was housed in special underwing pods replacing the usual drop tanks. The control system featured hydraulic actuators controlled by the YeS-3 autopilot.

The two testbeds were completed, tested and turned over to the air force in 1957. Tests of the K-10's guidance system continued into 1958; the Tu-16K-10 and the missile entered service with the Soviet naval air arm (AV-MF) in that year.

MiG-19 ARM testbed

Another production MiG-19 was used as a testbed for the guidance system of the first Soviet anti-radiation missile (ARM) – the Kh-58U used on the MiG-25BM, the air defence suppression ('Wild Weasel') version of the 'Foxbat'. Unfortunately, no details are available of this particular testbed, referred to in Russian documents as *imitahtor* (simulator).

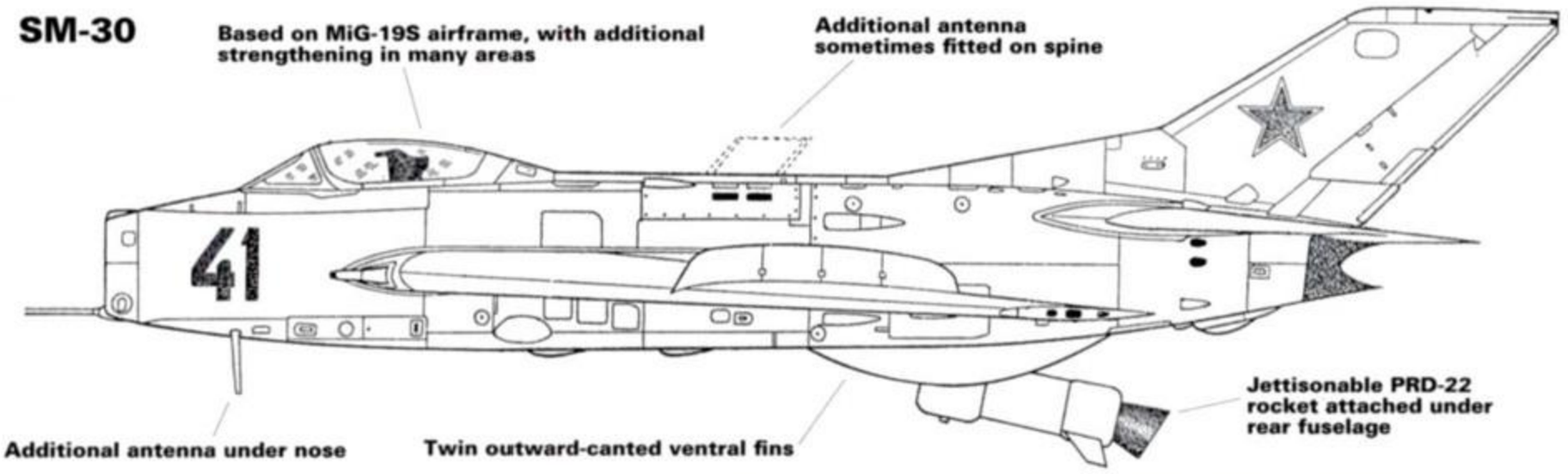
SM-30

In the late 1950s a zero-length launch (ZELL) system was under development in the USSR. Strictly speaking, the ZELL concept was nothing new. As early as 1942, the designer L. Golovin proposed it for his IVS escort fighter project. The system was tested in the USA on modified Republic F-84 Thunderjet, North American F-100A Super Sabre and later the Lockheed F-104 Starfighter. In the Soviet Union, ZELL interceptors were to be used where conventional air bases could not be built – e.g., along the northern borders, on the Novaya Zemlya nuclear test range or, in the event of war, on the forward edge of the battle area. Such fighters could blast off from small clearings a short way behind the front line, using forestation or high terrain as cover.

Under this concept, the Mikoyan OKB proposed a version of the MiG-19 launched from a trailer. The idea was supported in high places, and a decree of the Council of Ministers to this effect was issued in 1955. Mikhail I. Gurevich co-ordinated the MiG-19/ZELL effort, with A. G. Agronik appointed project chief.

The SM-30 differed from the standard MiG-19 in having a PRD-22 booster (PRD = *porokhovoy raketnyy dveegatel* – powder [i.e., solid-fuel] rocket motor) attached under the rear fuselage. The booster developed by I. I. Kartookov had a thrust impulse of 392.27 kN/seconds (131,233 lb/seconds) and fired for 2.5 seconds. This necessitated some structural modifications. The single ventral fin was replaced by shorter and recontoured twin fins canted outwards. Fuselage frames nos 15, 22, 24-26 and 30, the upper section of the inlet duct skin, wing/fuselage joints, no. 2 fuel tank bay and the attachments of nos 2 and 3 fuel cells were reinforced.

On the first prototype (SM-30/1), special locks were fitted to all control circuits between the stick (pedals) and the control actuators; they were released automatically after take-off but could be mechanically disengaged by the pilot in an emergency. A safety mechanism prevented the aircraft from blasting off with the gear down or the engines running at less than full power. To prevent injuries caused by the enormous *g*-loads during acceleration, the ejection seat was fitted with a special headrest securing the pilot's head.


SM-30
Based on MiG-19S airframe, with additional strengthening in many areas
Additional antenna sometimes fitted on spine
41
Additional antenna under nose
Twin outward-canted ventral fins
Jettisonable PRD-22 rocket attached under rear fuselage

The sight and sound of an SM-30 launch from its 15° ramp were spectacular; the launch caused considerable damage to anything that might have been behind the booster. Two aircraft were built for the programme, which proved to be remarkably successful.

The aircraft was delivered to the launch position on a 16-wheel semi-trailer with a massive beam and a traversing and elevating loading mechanism for transferring the aircraft to the launcher – a separate eight-wheel semi-trailer. On location, the launcher was readied for firing. The aircraft was pulled into position by an electric winch with the cable attached to the fuselage by special fittings. Then the aircraft was attached to the launcher's guide rails by specially-calibrated bolts and the launcher elevated 15°.

The pilot climbed into the cockpit using a portable ladder, started the engines, accelerated them to full military power, then switched on the afterburners and pushed the booster ignition button. When the booster fired, the calibrated bolts securing the aircraft sheared off and the aircraft lifted off, accelerating at 4.5*g*. Three seconds later the control locks were automatically disengaged, and by the time the booster burned out and was jettisoned the fighter was accelerating quickly. When the mission was over, the pilot landed as usual.

The launcher was designated PU-30 (*pooskovoye oostroystvo dlya* SM-30 – launcher for the SM-30) and towed by a YaAZ-210G conventional tractor (6x4). Once in position the aircraft was refuelled, and a fairly big trench had to be dug immediately aft of the launcher to deflect the blast and reduce soil erosion. This was necessary because the lift-off would produce a cloud of dust that could be seen for miles, and all stealth would be 'gone with the wind'.

In the autumn of 1956 the system was ready for testing. In its first flight the SM-30 was remote-controlled – just in case the thing chose to blow up instead of taking off. Eyewitnesses recalled later that the launch was an awesome experience. The thunder of the mighty rocket booster deadened the sound of the engines as the aircraft lifted off, belching a sheet of flame several times its own length. Two and a half seconds later the flames abruptly disappeared and the spent booster plunged earthwards while the SM-30 climbed away.

Inspection showed that the launcher was a total write-off. The longerons of the massive frame were warped by the intense heat of the booster flames and all transverse members were torn out by the jet blast. The message was clear: the launcher had to be fitted with a blast shield.

A new launcher incorporating the blast shield was built by April 1957 and tests resumed, with Georgi M. Shiyanov as project test pilot. Before making his first flight on the SM-30 he trained on a special launch simulator. On one occasion a technician arming the catapult made a mistake, placing the wrong charge and catapulting Shiyanov at 18*g* instead of 5*g*. Luckily, the pilot suffered no ill effects from this incident, and unwittingly demonstrated that the human body could absorb considerable *g* forces when the aircraft took off from the PU-30 launcher.

One of the SM-30s rests on its PU-30 launcher, the design of which caused some problems after the initial test. The fighter was transported to its launch site on a separate trailer.

The first manned flight was attempted on 10 April 1957 but had to be cancelled when the booster failed. In defiance of all superstitions, the attempt was repeated on 13 April and was successful; however, the booster exhaust went under the blast shield and lifted the launcher off the ground for a moment or two. The following incident recalled by N. N. Borisov, project engineer during the system's NII VVS tests, illustrates the enormous power of the blast.

"When tests at one firing position were completed and we moved to another location, the airfield maintenance team put the gas deflector pit to good use, dumping a mass of concrete left over from some construction work into it. However, the new location turned out to be a lemon and we had to go back to the old one. Extracting the huge lump of concrete from the pit was harder than getting it in, so we finally gave up and left the thing alone. Imagine our surprise when we looked into the pit after the aircraft had taken off. It was empty. The blast had propelled a lump measuring about 1 m³ (35 cu ft) right out of the pit."

The factory test programme was held jointly with LII. Shiyanov made the first five flights, and the sixth was made by S. N.

Rocket-launching of fighters showed some merits, especially in the defence of key targets and for Central European front operations. However, landing the aircraft always remained a tactical problem.

Anokhin. Several launches were made with full and partial fuel loads. On 3 June 1957 (some sources state 3 July), Anokhin made the seventh take-off with a full payload comprising two standard 760-litre (176-Imp gal) drop tanks and two FFAR pods. During the test programme the aircraft was modified to decrease the longitudinal *g* loads during take-off. A special conical brake parachute deployed before touch-down was also tested. After the eighth test flight performed by Shiyanov, the launcher and the unnumbered first prototype were transferred to NII VVS for state acceptance trials.

The second prototype, SM-30/2 ('Red 41'; c/n 59210401?), differed from the first in having no provision for aileron locking, a further reinforced fuselage frame no. 30, and elevators fixed at a different angle for take-off.

At NII VVS the aircraft was flown by test pilots V. G. Ivanov (PVO) and M. S. Tvelenev, plus check-out pilots L. M. Kuvshinov, V. S. Kotlov, N. P. Troosov, A. S. Blagoveschchenskiy, S. A. Mikoyan and Georgi T. Beregovoy. All made a single catapult-launched flight, except Ivanov who made six flights. Shiyanov topped the list with 11 blast-offs from the PU-30 launcher, for which he was later awarded the Hero of the Soviet Union title; Anokhin was second with seven catapult-launched flights. The test programme allowed the *g* loads the pilot experienced at take-off to be measured; they did not exceed 5*g*.

The protocol of the state acceptance trials read as follows: 'Take-off in the SM-30 is easy and can be performed by pilots familiar with the MiG-19. The pilot feels more comfortable during take-off if the controls are unlocked because he can take corrective action at any moment. Installing control locks is thus inadvisable. Building a small pre-production batch is recommended in order to evaluate the system's combat potential. It is necessary to develop a reliable system enabling the aircraft to land on short strips away from air bases.'

N. N. Borisov recalled that, since the controls were locked during the first three seconds when the pilot was subjected to 5*g*, a special handle was fitted to the instrument panel for the pilot to hold grip. However, test pilot V. G. Ivanov was extremely unhappy with the control locks and demanded their removal after making his first flight on the SM-30. The control locks functioned perfectly throughout the test programme.

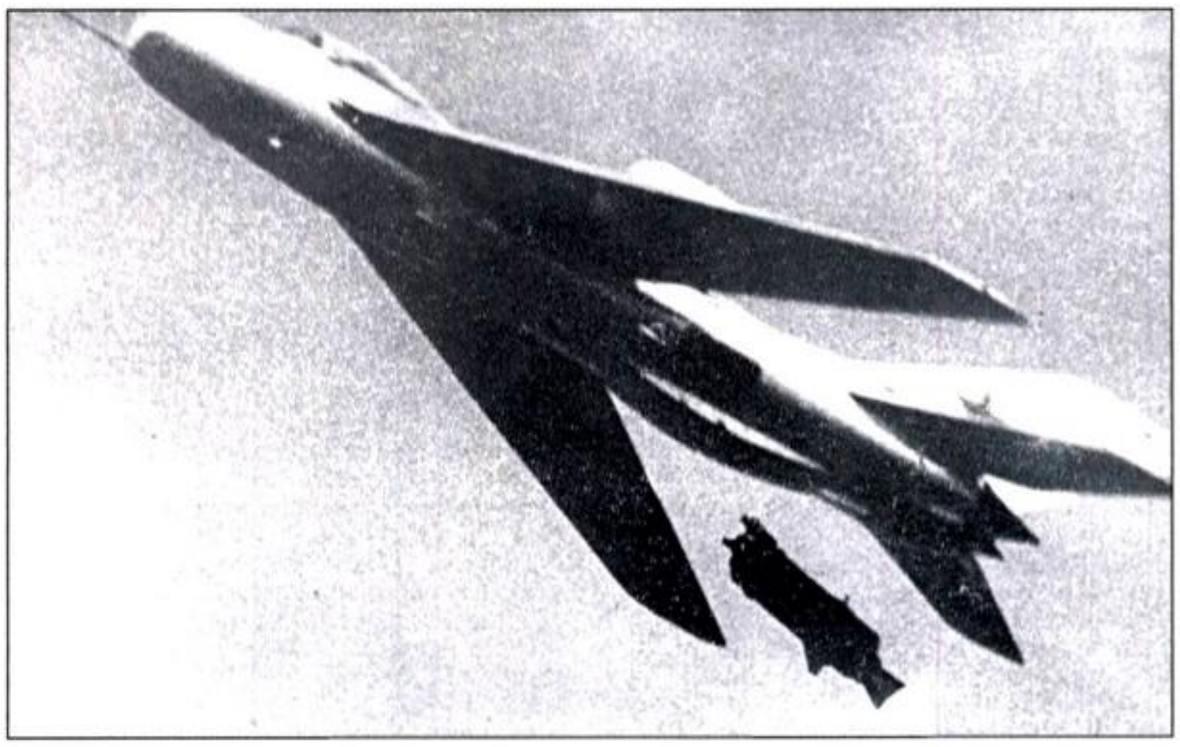
Two aircraft and two (possibly three) PU-30 launchers were built, though some sources state a total production run of five aircraft and six launchers. After the state acceptance trials, the Mikoyan OKB decided to demonstrate the aircraft to the Minister of Defence, Marshal Georgi K. Zhukov, and other top-ranking officers. As often happens during such demonstrations to the top brass, the system malfunctioned on the first try. However, the problem was quickly fixed and the aircraft blasted off a few minutes later with Shiyanov at the controls. The spectators were very impressed.

The SM-30 had a top speed of 1450 km/h (900 mph), a service ceiling of 17500 m (57,414 ft) and climbed to 10000 m (32,808 ft) in 1.1 minute. Range with drop tanks was 2200 km (1,366 miles).

Having perfected the launch technique, the designers were faced with an equally challenging task – landing the SM-30 on a strip no more than 400 m (1,312 ft) long. A series of test flights was made by K. K. Kokkinaki. The standard brake chute proved insufficient, so new methods of slowing the aircraft had to be devised. The first was very unorthodox: a nylon rope was stretched across the landing strip with a number of parachutes at either end. The aircraft engaged the rope with the nose gear, inflating the parachutes. However, this technique turned out to be very inconvenient, even though the desired effect was obtained. Therefore, a tactical airfield arrester system was envisaged, with a steel cable, a number of pulleys and a hydraulic braking device. A MiG-19SV specially equipped with an arrester hook could be stopped within 120 m (393 ft) of the engagement point with a *g* load not exceeding 2*g*. However, the test programme was not completed because the government terminated the SM-30 programme.

One of the reasons that the ZELL system was not adopted was the fighter's need for an airfield for landing. Additionally, the transporter and launcher were bulky and too tall to go through tunnels or under power wires at railroad crossings. Finally, anti-aircraft missile systems were by then being fielded, and the government's interest in the SM-30 waned.

When the PRD-22 booster burnt out, it fell away. The SM-30 was launched in full afterburner, and accelerated quickly enough to allow a rapid climb-out.



SM-30/3

Even as the SM-30 was being put through its paces, the Mikoyan OKB was developing a parallel project – a short-take-off (STO) version of the MiG-19 capable of operating from short tactical strips. By the time state acceptance trials began it was clear that the ZELL version was complicated and needed full-size airfields for landing, and was thus unfeasible, all its advantages notwithstanding. Therefore, the STO version had a better chance of being adopted by the PVO.

The SM-30/3 was to be equipped with two PRD-23 jet-assisted take-off (JATO) bottles mounted in such a way that their thrust vector passed through the aircraft's centre of gravity and their operation did not impair stability. The bottles were jettisoned after take-off. However, this version did not get off the drawing board.

SM-50 (MiG-19SU)

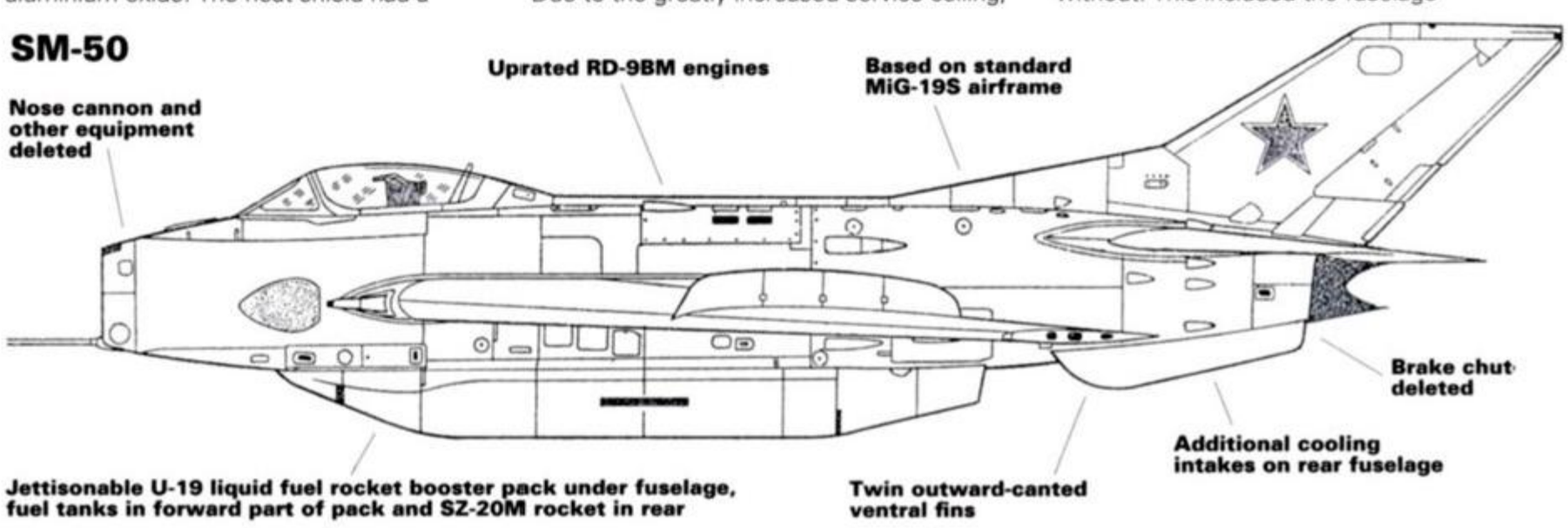
In the late 1950s, incursions into Soviet airspace by high-flying USAF reconnaissance aircraft were becoming steadily more frequent. The best Soviet high-altitude interceptor of the time – the MiG-19SV – had a service ceiling of only 18500 m (60,695 ft), and even these aircraft were in short supply. Meanwhile, the Lockheed Aircraft Company was finalising its U-2 spyplane which could fly much higher and would be beyond the reach of Soviet interceptors. Therefore, Soviet fighter design bureaux were tasked with increasing the service ceiling of interceptors.

This was possible only by fitting a rocket booster. The Mikoyan OKB converted a standard MiG-19S into an experimental aircraft designated SM-50. In some documents the aircraft is also referred to as the MiG-19SU (U = *ooskoreetel* – booster). The standard RD-9B engines were replaced by RD-9BM turbojets rated at 31.38 kN (7,098 lb st) with NR-11AE and NR-11VE fuel pumps. A streamlined jettisonable pod housing a U-19 disposable liquid-fuel rocket booster was mounted under the fuselage.

The forward fuselage incorporated fittings for the booster's fuel and oxidiser tanks housed in the pod, and attachments (anchor nuts) for the pod itself. A ventral well was made in the aft fuselage, housing the rocket motor's bearer frame and a concave steel heat shield coated with aluminium oxide. The heat shield had a double skin and was air-cooled. The single ventral fin was replaced by recontoured twin fins canted outwards, and additional cooling air intakes were provided for the lower actuators of the turbojets' nozzles.

There were some equipment changes, too. An experimental Kaskad command link (guidance) system was fitted, and the aerials of the MRP-56P marker beacon receiver and ARK-5 ADF were relocated. Due to the greatly increased service ceiling, the standard KKO-1 oxygen system was replaced by a larger KKO-2 set, the barometric altimeter and Mach meter were replaced, and the pilot used a new VKK-3 pressure suit. (Some documents designate the oxygen system and pressure suit as KKO-2M and VKK-3M, respectively.)

To compensate for the added weight of the booster the aircraft was lightened by removing every possible item it could do without. This included the fuselage-


SM-50
Uprated RD-9BM engines
Based on standard MiG-19S airframe
Nose cannon and other equipment deleted
Brake chute deleted
Additional cooling intakes on rear fuselage
Jettisonable U-19 liquid fuel rocket booster pack under fuselage, fuel tanks in forward part of pack and SZ-20M rocket in rear
Twin outward-canted ventral fins

The rocket booster pack of the SM-50 was self-contained, requiring only an electrical supply and attachment points. The aircraft's structure, however, needed localised strengthening to absorb the additional loads imposed by the brutal acceleration forces.

mounted gun and its ammunition box, the pylons for the ORO-57K FFAR pods, the forward airbrake, the ESKR-46 signal flare launcher, the RV-2 radio altimeter, the Sirena-2 RHAWS, the fire extinguishers and brake chute. Nevertheless, gross weight rose to 9000 kg (19,841 lb), so the nitrogen pressure in the landing gear oleos had to be increased.

Fuel cells nos 3 and 4 were removed because the rocket motor and heat shield installed in their respective places left no room for them. The aircraft could be flown with drop tanks, but only if the booster was unrefuelled.

The U-19 booster was built around the SZ-20M liquid-fuel rocket motor designed by L. L. Sevrook and A. M. Isayev. Other components included tanks for TG-02 hypergolic (i.e., self-igniting) fuel, AK-20 oxidiser (called TT-S2 in some documents) and hydrogen peroxide, a neutral gas pressurisation system, a system of pyrovalves and piping. When fully refuelled the booster operated for 3½ to 4 minutes at minimum thrust (12.75 kN/2,865 lb st) or two minutes at full thrust (29.42 kN/6,613 lb st). The booster was self-contained, being connected to the aircraft's systems only electrically (for rocket motor ignition and emergency fuel jettisoning).

The KKO-2 (KKO-2M) oxygen equipment allowed the pilot to stay at 20000 m (65,616 ft) for 5 to 10 minutes or at 24000 m (78,740 ft) for 3 to 4 minutes in the event of decompression. The VKK-3 (VKK-3M) pressure suit was used with a GSh-4 heated pressurised helmet so that the pilot could work at altitudes of up to 24000 m. The suit was switched on at 12000 m (39,370 ft), automatically maintaining a pressure equal to the atmospheric pressure at 12000 m. There was also a KP-27M oxygen bottle to be used in the event of an ejection.

The SM-50 (MiG-19SU) was ready for factory tests in the early days of December 1957, and the test programme was completed before the month was over. Test pilot M. M. Kotel'nikov made the first flight; V. A Nefyodov and G. A. Sedov also flew the aircraft, with Yu. N. Korolyov as project engineer. In one sortie Sedov reached 24500 m (80,380 ft) in a zoom climb. The SM-50 climbed to 20000 m in just eight minutes. Top speed with the rocket booster on was 1800 km/h (1,118 mph), and ceiling in sustained flight grew to 23000 m (75,459 ft). Range was 800 km (496 miles).

The aircraft was later tested at LII by A. P. Bogorodskiy, V. P. Vasin and V. G. Mookhin. The PVO command ordered that the test programme be held at the PVO training centre located at Savostleyka air base, a long way from Moscow, in order to prevent information about the SM-50 from leaking to the West.

The rocket booster did improve the aircraft's performance considerably, but the designers had neglected to define ground handling and servicing procedures. The highly toxic fuel components were often emptied onto the ground, causing damage not only to the environment but to the ground personnel's health.

Upon completion of the factory test programme the aircraft was transferred to NII VVS for state acceptance trials, which were performed by air force test pilots P. F. Kabrelev and S. V. Petrov and Mikoyan test pilot V. A. Nefyodov under the supervision of project engineer V. P. Belodedenko. PVO pilots A. L. Ivanov, I. I. Pavlov and Col. Gen. Yevgeni Ya. Savitskiy (he went on to become PVO C-in-C) also made two flights each in the SM-50. Some documents state that LII test pilot A. A. Schcherbakov flew the aircraft.

The SM-50 could fly both with and without the U-19 booster; the latter was usually jettisoned after burnout. Pilots reported that when the booster was ignited at about 17000 m (55,774 ft), rate of climb often reached 120 m (393 ft) per second. During the trials programme the SM-50

attained 24000 m (78,740 ft) and Mach 1.6. The pilots tried to maintain straight and level flight with the booster engaged at 20000 m (65,616 ft) and 22000 m (72,178 ft), but the aircraft was firmly intent on climbing, refusing to stay in level flight for more than 100 and 67 seconds, respectively. Time to service ceiling varied from 9.5 to 11 minutes. The hardest part of the mission was to maintain the correct trajectory, since the booster required a *g* load of at least 0.3-0.5*g* to operate normally.

The augmented gross weight caused unstick speed to grow markedly, reaching 395 km/h (254 mph). Special care had to be given to the wheels to avoid the low-mounted booster making contact with the ground, since the booster was filled with highly toxic and explosive fuel components and a leak could be disastrous.

MiG-19SV high-altitude fighters served as practice targets during the trials programme. The SM-50 was a fairly high-performance aircraft for the late 1950s. However, to use the combined thrust of the engines and booster to the best advantage the pilot had to carefully choose the moment of booster ignition and plan the trajectory. Spotting the target with the naked eye at over 20000 m (65,616 ft), getting it into the crosshairs of the sight and blasting it with the guns in just one firing pass was virtually impossible, considering the short burn time of the booster and the *g* loads.

Accurate ground guidance was necessary, and the targeting techniques based on the Kaskad command link system (which had yet to be tested) were far from perfect. Finally, the new S-75 Tunguska (SA-2 'Guideline') anti-aircraft missile system became operational with the PVO, augmenting the earlier S-25. All of this stopped the SM-50 from entering production, but five standard MiG-19S fighters were converted to SM-50s at the Gorky plant. The test programme gave valuable information on piloting techniques and the behaviour of turbojets at altitudes up to 24000 m (78,740 ft).

SM-51/SM-52 (MiG-19PU)

Two production MiG-19P interceptors were converted in 1957 to a configuration similar to the SM-50. The aircraft were equipped with a U-19D liquid-fuel rocket booster based on the RU-013 disposable rocket motor designed by L. S. Dooshkin (hence the D). The aircraft was designated MiG-19PU (PU = *perekhvatchik s ooskoreetelem* – booster-equipped interceptor) and the two prototypes were known as SM-51 (SM-51P) and SM-52 (SM-52P), respectively.

The Mikoyan OKB delivered the working drawings for the MiG-19PU to the Gorky plant with a view to building an experimental batch. Meanwhile, the OKB's experimental plant manufactured several shipsets of rocket motor bearer frames, valves, cocks, etc., both for bench testing purposes and for use in modifying the aircraft in Gorky.

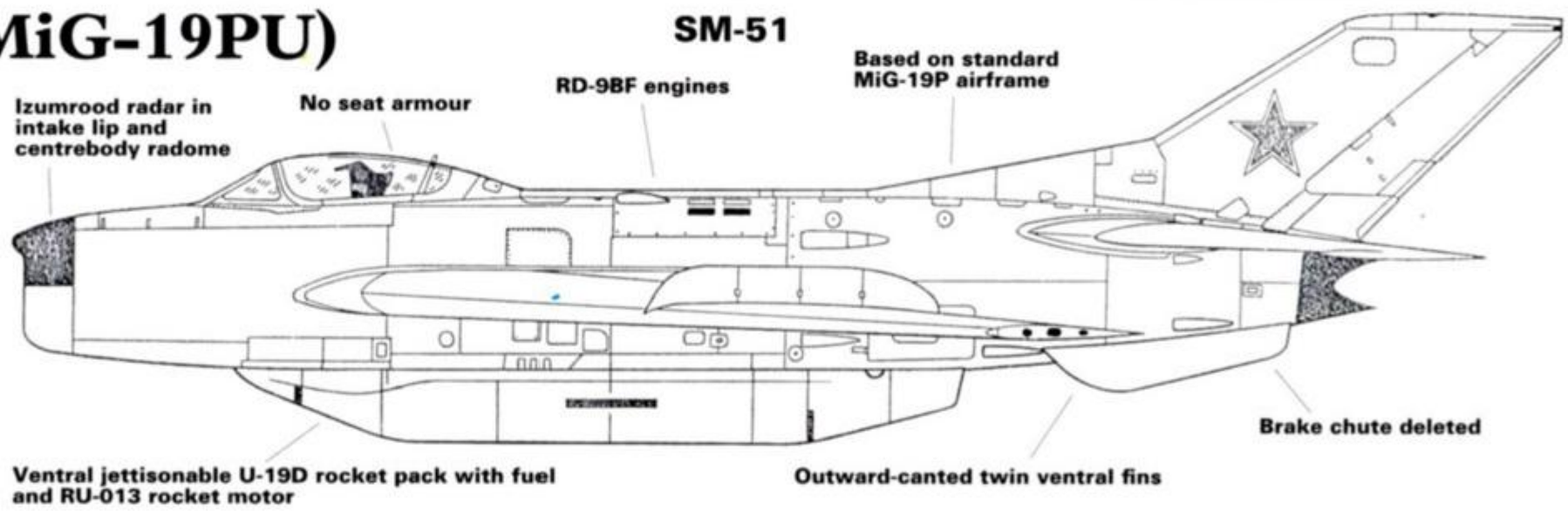
The pre-production batch of MiG-19PU interceptors was completed in 1958. Besides having the U-19D rocket booster, they differed from the standard MiG-19P in having RD-9BF engines rather than the usual RD-9Bs, new reinforced wheels, no armoured seat back/headrest, no provision for FFAR pods, no front airbrake, no brake chute, and only two fuel cells (nos 1 and 2).

As on the SM-50, the booster was completely self-contained, being connected to the aircraft's systems only electrically for ignition and emergency fuel jettisoning. The attachments were identical to those of the earlier U-19, so the two boosters were interchangeable. The RU-013 rocket motor weighed 338 kg (745 lb), plus 372 kg (820 lb) of fuel, 112 kg (247 lb) of oxidiser and 74.2 kg (163.5 lb) of hydrogen peroxide. Drop tanks could only be carried when the booster was not fitted. The armament – two wing-mounted NR-30 guns – remained unchanged.

As with the SM-50, the SM-51P was flown by V. A. Nefyodov, with Yu. N. Korolyov as project engineer. Tests showed that top speed had increased to 1930 km/h (1,198 mph) and service ceiling to 24000 m (78,740 ft). Still, the MiG-19PU did not enter large-scale production because, like the SM-50, it could stay at high altitudes only briefly. Nor did the newly-developed K-5 (RS-2-U) AAMs help, because they had semi-active radar homing and destroying the target required tracking it for a considerable time.

An improved U-19M (M = *modernizeerovannyy* – upgraded) booster designed around the Sevrook SZ-20M5 rocket motor was under development in 1957-58. This booster could last five sorties and was intended for the MiG-19SU (SM-50), MiG-19PU (SM-51P/SM-52P) and the SM-12PMU then under development.

The second MiG-19PU conversion, a.k.a. SM-52 or SM-52P, differed from the first


SM-51
Izumrood radar in intake lip and centrebody radome
No seat armour
RD-9BF engines
Based on standard MiG-19P airframe
Brake chute deleted
Ventral jettisonable U-19D rocket pack with fuel and RU-013 rocket motor
Outward-canted twin ventral fins

aircraft in having new mission avionics (the aircraft was effectively an avionics testbed). The standard Izumrood (Emerald) gun ranging/target illumination radar was replaced by a new Almaz (Diamond) radar and SRD-5A Baza-6 (Base) rangefinder. This aircraft was also used to test the Gorizont-1 (Horizon) command link system and the Svod LORAN that automatically determined the aircraft's position (range and azimuth with respect to a ground beacon) in IFR conditions.

This is one of the MiG-19PU batch, seen without its ventral rocket booster.

SL-19

A MiG-19 was converted at LII into a research vehicle designated SL-19 (SL = *samolyot-laboratoriya* – 'laboratory aircraft', i.e., research aircraft or testbed). It was fitted with a skid undercarriage, the track and 'skidbase' of which could be varied widely.

MiG-19/APB-1 testbed

Between 1958 and 1962 a production MiG-19 (exact model unknown) was used by LII as a testbed for the automatic landing system built around the APB-1 autopilot.

SM-11

In 1956 a production MiG-19S was fitted experimentally with a Yastreb (Hawk) infra-red search and track (IRST) unit for night intercept sorties. The IRST locked on to 'hot' parts of the target, enabling the pilot to detect it and determine the direction of its travel at night or high altitude.

The IRST was to be housed in an increased-diameter nose section, with the IR sensor located centrally in the air intake. The IRST display and a SIV-52 (SIV = *samolyotnyy infrakrasnyy veezeer* – aircraft-mounted IR sight) were to be installed in the cockpit. The IR sight displaying target range was slaved to the regular gunsight.

MiG-19 armament tests

SM-2/A

In 1955 the Mikoyan OKB converted an early-production Gorky-built MiG-19 ('Red 420', c/n 59210420) into a ground attack aircraft designated SM-2/A armed with 70-mm (2.75-in) ARS-70 unguided rockets. The aircraft could carry either two rocket pods with five rockets each on Model 369-Sh cradles and two drop tanks, or four rocket pods and no drop tanks (two pods were carried on the 'wet' hardpoints). Sighting when firing the guns or rockets was done with the ASP-5N-V2 sight linked to the Radal'-M gun ranging radar. Additional whip aerials were located low on the forward port fuselage. An SSh-45 gun camera was fitted. The SM-2/A was tested and found satisfactory.

SM-2/B

In the same year, another early-production Gorky-built MiG-19 ('Red 406', c/n 59210406) was fitted with ORO-190K launchers, each firing a single 190-mm (7.5-in) TRS-190 unguided rocket. The aircraft could carry either two launchers with five rockets each on Model 369-Sh cradles and two drop tanks or four launchers on Model 369-Sh cradles and no drop tanks. Except for the armament, the aircraft was identical to the SM-2/A. This aircraft, known as the SM-2/B, was also tested successfully in 1957.

The SM-6 was a testbed for the K-6 missile, carrying two weapons under the main wing pylons. Note the teardrop fairing for a ciné camera under the wingroot.

SM-2/V

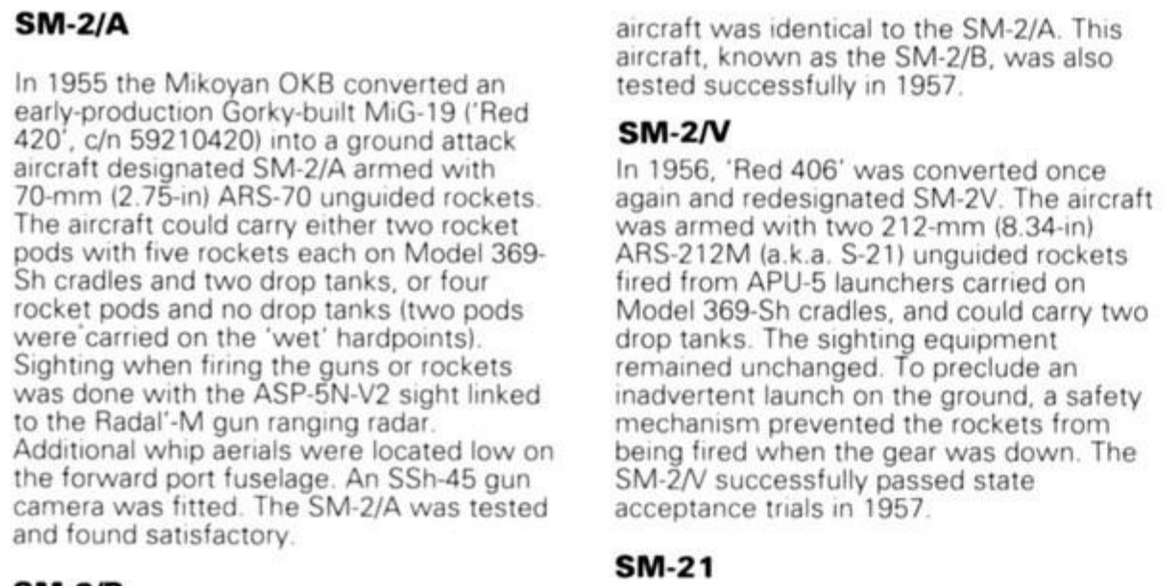
In 1956, 'Red 406' was converted once again and redesignated SM-2V. The aircraft was armed with two 212-mm (8.34-in) ARS-212M (a.k.a. S-21) unguided rockets fired from APU-5 launchers carried on Model 369-Sh cradles, and could carry two drop tanks. The sighting equipment remained unchanged. To preclude an inadvertent launch on the ground, a safety mechanism prevented the rockets from being fired when the gear was down. The SM-2/V successfully passed state acceptance trials in 1957.

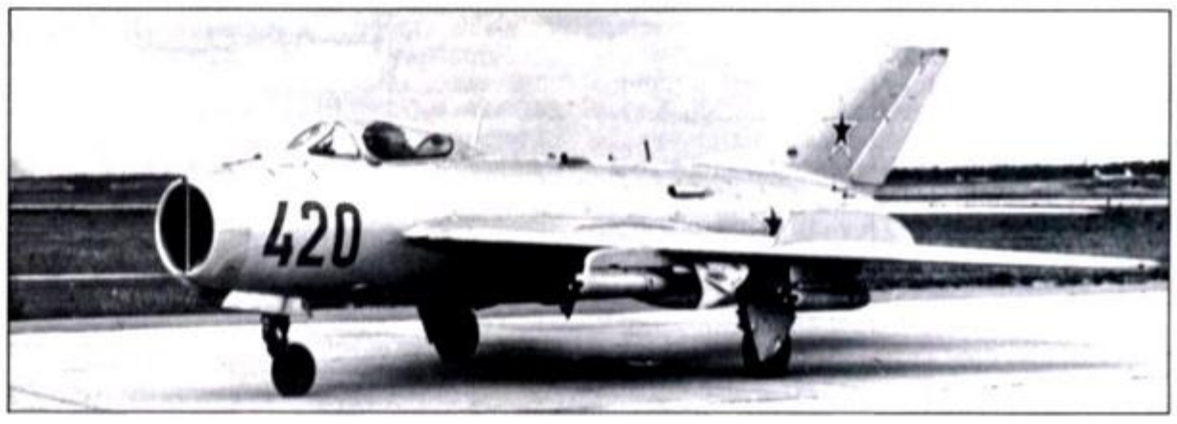
SM-21

Also in 1956, the same aircraft was successfully tested with the APU-5 launchers moved outboard to the drop tank hardpoints. The various configurations of the SM-2 were designated by letters in Cyrillic alphabetical order; logically, this version should have been the SM-2/G but the aircraft was known as the SM-21 (after the S-21 rockets it carried).

SM-2/D

In 1957 the SM-2/A ('Red 420') was refitted with four rocket pods firing nine 85-mm (3.34-in) TRS-85 unguided rockets and redesignated SM-2/D. In all other respects the aircraft remained unchanged.





'Red 406' and 'Red 420' were the two early-production MiG-19s used extensively on ground attack rocket tests. Shown above is '420' in SM-2/A guise, with four ARS-70 rocket pods, while below is '406' in SM-21 configuration with ARS-212 rockets.

SM-2/I

This again is an out-of-sequence designation, since the SM-2/E, SM-2/Zh and SM-2/Z never existed. A production Gorky-built MiG-19 (c/n 59120540; no tactical code was applied) was converted into a weapons testbed for the K-6 (AA-1 'Alkali') AAM developed for the MiG-19PM. No target illumination radar was fitted and the wing guns (which are deleted on the MiG-19PM) were retained. The SM-2/I participated in two trials programmes in 1957, making a total of 10 live launches.

SM-2/M

This was the final version of the SM-2 with another out-of-sequence suffix letter (the SM-2/K and SM-2/L never existed). The aircraft was converted in 1955 to test the K-5M AAM (a.k.a. RS-2-US). Two missiles were carried on APU-5M pylons mounted near the wing guns on Model 369-Sh cradles. A similar arrangement was later used on MiG-19Ps retrofitted with two missile pylons.

SM-6

Attempting to improve the MiG-19P's armament, in 1956 the Mikoyan OKB fitted two production aircraft with two K-6 AAMs tested earlier on the SM-2/I. Designated SM-6, the two aircraft were equipped with an Almaz-3 target illumination radar and had the guns deleted. The missiles were carried on APU-5M-K pylons mounted at the usual drop tank hardpoints. Two ciné cameras (E-13-300 and AKS-2) were carried in pylon-mounted pods under the inner wings to record missile launches.

The test programme included determining target detection and lock-on range, target tracking accuracy and the general reliability of the radar. Various versions of the K-6 were launched to determine their performance, including stability and manoeuvrability characteristics.

MiG-19M

The design bureau led by Semyon M. Alekseyev developed a plan to convert obsolete MiG-19 and MiG-19S fighters into remote-controlled target drones designated MiG-19M (M = *mishen* – target). The drones were used to train PVO crews.

SM-12

It is an established fact that air intake design affects an aircraft's performance to a considerable degree. Engine thrust and hence performance figures are in reverse proportion to the pressure losses in the inlet duct. At Mach 1.5, pressure losses in an intake designed for subsonic speeds can reach 15 per cent. The MiG-19's intake design with a rounded lip inherited from the MiG-15 and MiG-17 was efficient at subsonic speeds but generated excessive drag at supersonic speeds.

The North American F-100 Super Sabre had an intake with a sharp lip. This, combined with the generally clean lines of the airframe and a thrust-to-weight ratio of 0.495 at sea level, gave the fighter a top speed of 1390 km/h (863 mph). The MiG-19 had a much better thrust-to-weight ratio (0.86) but a top speed of only 1452 km/h (902 mph) at 10000 m (32,808 ft).

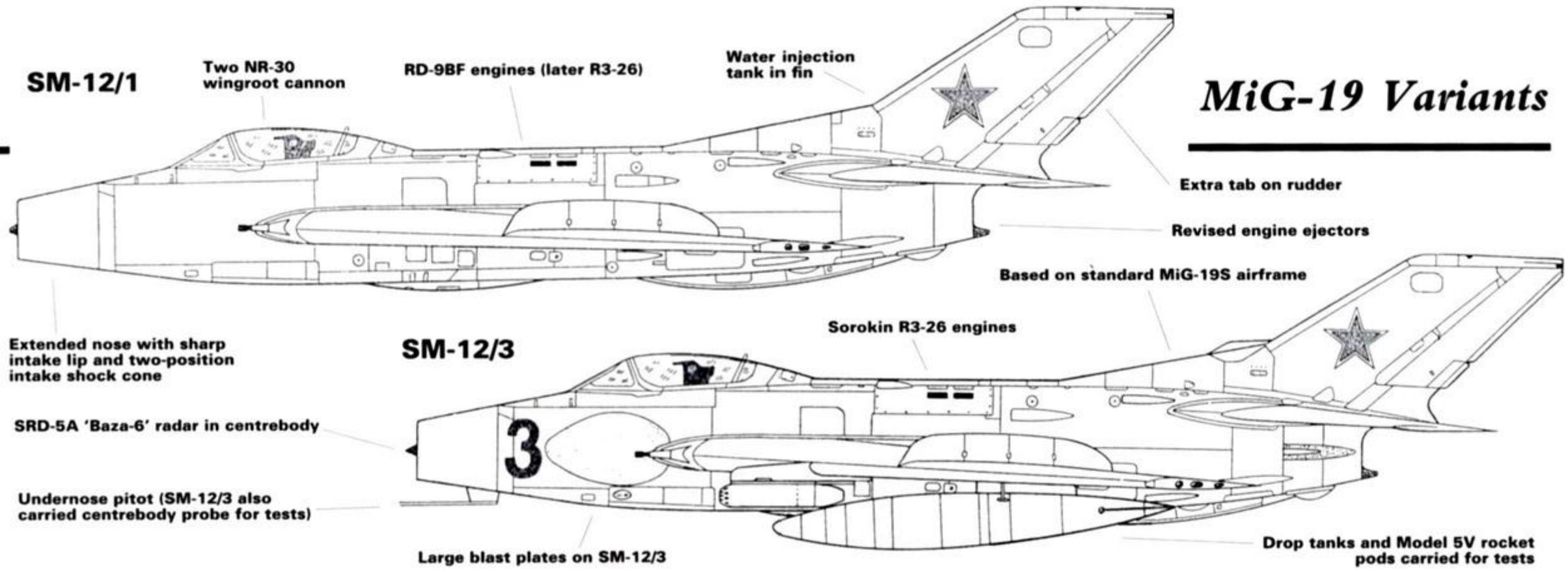
Therefore, the Mikoyan OKB decided to try mating the sharp-lipped air intake tested earlier on the Ye-2A and Ye-5 prototypes (precursors of the MiG-21F 'Fishbed-A') to the MiG-19 in order to decrease pressure losses in the inlet duct.

The drawings of a lengthened nose section with straight contours like those of the MiG-21F and a movable intake centrebody (shock cone) were ready in 1956. The MiG-19's characteristic forked tailcone between the engine nozzles was modified to reduce size and weight, and a water-injection system was developed for increasing engine thrust.

The Gorky plant was tasked with building four prototypes of the SM-12, as the aircraft was designated. Three of the prototypes had been completed by the end of 1956 and differed in minor details such as pitot tube location.

In early 1957 the first and third prototypes entered flight test. The SM-12/1 differed from the standard MiG-19S mainly in having a new nose section up to fuselage frame no. 2, featuring a sharp-lipped air intake with a two-position shock cone. Cone travel was 25 cm (9.9 in); in the aft position the cone protruded 20 cm (7.9 in) beyond the intake lip. A water tank for the water-injection system was installed at frame no. 1. Another water tank holding 150 litres (33 Imp gal) was incorporated in the fin. The lateral skins of this tank with integral

The new nose of the SM-12 radically altered the look of the aircraft compared to the standard MiG-19. This is the SM-12/1.


SM-12/1
Two NR-30 wingroot cannon
RD-9BF engines (later R3-26)
Water injection tank in fin
Extra tab on rudder
Revised engine ejectors
Extended nose with sharp intake lip and two-position intake shock cone
SM-12/3
Based on standard MiG-19S airframe
Sorokin R3-26 engines
SRD-5A 'Baza-6' radar in centrebody
Undernose pitot (SM-12/3 also carried centrebody probe for tests)
Large blast plates on SM-12/3
Drop tanks and Model 5V rocket pods carried for tests

stringers were chemically milled from D16ATL10 aluminium sheet.

The RD-9B engines were replaced by RD-9BFs (originally, RD-9BF-2s uprated to 40.21 kN/9,038 lb st were to be fitted but these engines were not ready yet). The tailcone from fuselage frame no. 35 onwards was modified to fit the new engines, with frames and inner skins made of heat-resistant steel and outer skins made of AK-4-1 aluminium alloy. New ejectors were fitted around the nozzles, and a new steel heat shield was installed in the engine bay.

A new APS-4MD electric stabilator actuator (APS = *agregat perestanovki stabilizahtora* – stabiliser control unit) was installed, increasing stabilator movement rate more than four times. The fuselage-mounted gun was deleted. The SRD-1M Konus gun ranging radar was replaced by the SRD-5A Baza-6 radar housed in the dielectric intake centrebody. A Bariy (Barium) IFF transponder replaced the usual Khrom (Chrome, 'Odd Rods') unit. The nose gear doors, the ventral fin and the spent ammunition collectors were modified, PVD-4 pitot tubes were installed at the wingtips, and the rudder was fitted with a trim tab.

The third prototype, SM-12/3, incorporated additional changes. The most important change was the experimental R3-26 turbojets rated at 37.27 kN (8,377 lb st) in full afterburner. Pitch and roll control reliability was increased by substituting the standard BU-14MS and BU-13M actuators with BU-14MSK and BU-13MK, respectively. An SIV-52 IR sight linked with the ASP-5NV-4 gunsight and SRD-5A Baza-6 gun ranging radar was fitted.

The R3-26 was evolved from the RD-9BF by a division of the Mikulin OKB in Ufa (Bashkiria) headed by V. N. Sorokin. It differed from the production engine in having a three-stage afterburner ignition system, a pressure growth limiter in the main fuel line, changes to the compressor, turbine and afterburner, and some reinforced parts. It was also less prone to surging when the boundary layer bleed strip was closed.

The SM-12/3 had KT-37 mainwheels and a KT-38 nosewheel, all three of which were equipped with dual disc brakes. The avionics fit included an RSIU-4V radio, an ARK-5 ADF, an RV-2 radio altimeter, an MRP-56P marker beacon receiver and an SRO-2 Khrom IFF transponder. As on the first prototype, the intake centrebody housed the SRD-5A Baza-6 radar working together with an ASP-5NV or ASP-5NM gunsight. The radar's detection range was 300-3000 m (984-9,842 ft).

In addition to the two wing-mounted NR-30 guns with 73 rpg, the armament of the SM-12/3 comprised four Model 5V rocket pods with ARS-57 or ARS-57M FFARs; two were carried on pylons with Model 369-E shackles, the other two on the drop tank hardpoints with BDZ-56 (Model 369-Sh) shackles. Alternatively, two 50-kg (110-lb), 100-kg (220-lb) or 250-kg (551-lb) iron bombs could be carried on the drop tank hardpoints.

Like the SM-50, the aircraft was equipped with a KKO-2M oxygen system. The pilot used a VKK-3M pressure suit, a GSh-4 pressurised helmet and a KP-27M oxygen bottle (used in the event of an ejection).

Mikoyan test pilot K. K. Kokkinaki made the first flight and performed the main part of the factory test programme on the first and third prototypes; only the latter had a tactical number ('Red 3'). The SM-12/1 initially flew with RD-9BF engines but was later refitted with R3-26s in order to hasten the latter engine's test programme. The SM-12/3 attained a top speed of 1930 km/h (1,198 mph) and climbed to its service ceiling of 18000 m (59,055 ft) in 3.2 minutes. The tests showed that the impressive gain in speed – almost 500 km/h (310 mph) – and ceiling was attributable solely to the new air intake design without major structural changes, an increase in take-off weight or any sizeable increase in thrust.

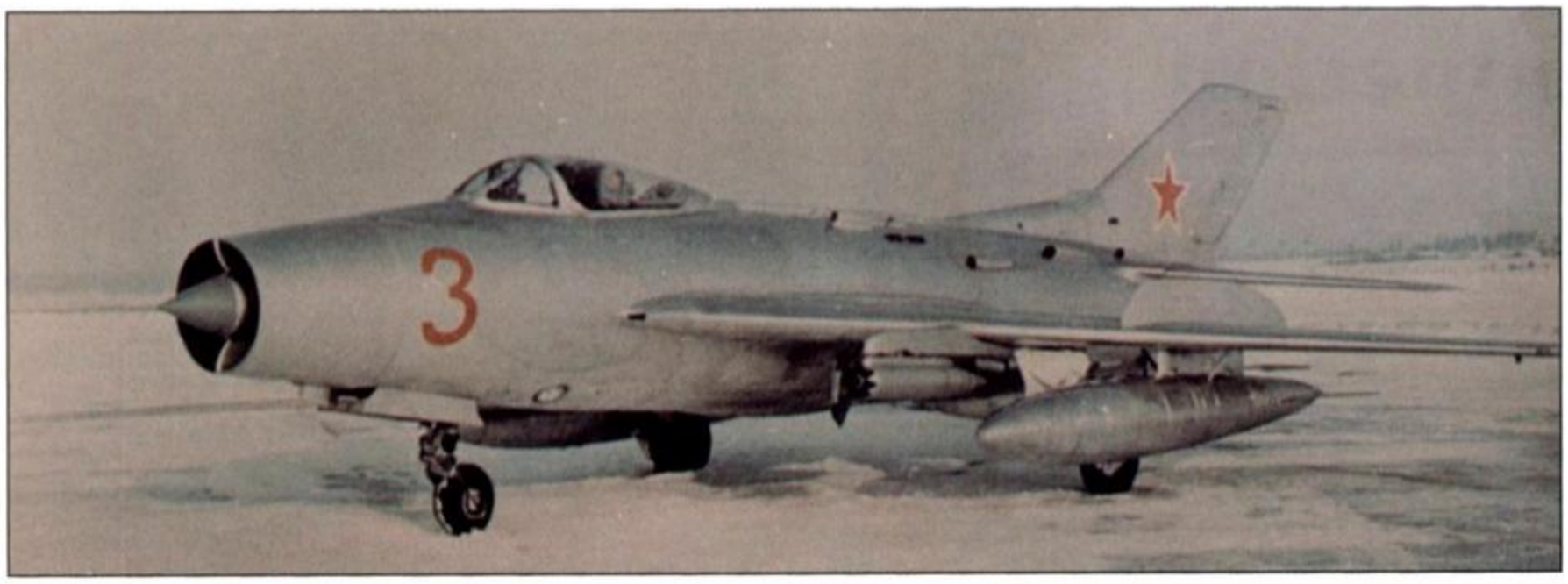
The fourth prototype, SM-12/4, took some time to build because the Mikoyan OKB had decided to complete it with all changes found necessary after testing the first three aircraft. It reached the final assembly stage by late 1957.

Between 17 March and 27 August 1957, the first and third prototypes underwent state acceptance trials at NII VVS. The SM-12/3 had by then been recoded 'Red 34' by simply painting in an extra digit The aircraft were flown by Colonels L. M. Kuvshinov, S. A. Mikoyan and V. S. Kotlov, with Major K. M. Osipov as project engineer. Lieutenant General A. S. Blagoveschchenskiy, and Colonels Molotkov, Yuri Antipov, G. T. Beregovoy, M. S. Tvelenev and Zakharov also tried the SM-12.

Between them, the two aircraft made more than 150 flights in all. The SM-12/1 was used solely as an engine testbed, while the main part of the programme was completed on the SM-12/3. During the state acceptance trials the third prototype attained 1926 km/h (1,196 mph) at 12500 m (41,010 ft). The service ceiling was recorded as 17500 m (57,414 ft). Rate of climb had decreased slightly compared with the MiG-19S, but it was still twice that of the F-100C: the aircraft climbed to 10000 m (32,808 ft) in two minutes and to 15000 m (49,212 ft) in four minutes if flown clean, i.e., without drop tanks. The SM-12 was capable of a supersonic dash at 20000 m (65,616 ft).

The SM-12/2 was little used in the flight tests. It featured a small blast plate next to the cannon.

The SM-12/3 is seen with two (below) and four (left) Model 5V rocket pods.



Some shortcomings were also discovered. Lateral stability was inadequate at high Mach numbers, especially if the aircraft was pulling *g*. Stick forces required to counter a roll if an aileron actuator failed at supersonic speed had grown considerably, which was dangerous. On the whole, however, the aircraft was broadly similar in handling to the MiG-19S. The engines ran smoothly when the aircraft let loose a salvo of FFARs.

Generally, the SM-12 was almost equal in combat capabilities to the Ye-2A and Ye-5 but could be put into production much quicker, having more than 80 per cent commonality with the production MiG-19S. Still, the NII VVS commission holding the state acceptance trials recommended that production start be delayed until a production-standard SM-12 was tested and all deficiencies detected during the trials were rectified.

However, this was never done. The Ye-6 (MiG-21F prototype) had by then almost completed its flight test programme and was clearly more promising than the MiG-19 family; the Gorky factory was already preparing for large-scale production of the type. The SM-12 programme was probably no more than an insurance policy in case the Ye-6 failed.

SM-12/3T and SM-12/4T

Upon completion of the state acceptance trials, the third and fourth SM-12 prototypes were fitted with two pylons for K-13 AAMs and redesignated SM-12/3T and SM-12/4T, respectively. The aircraft also served as testbeds for the new Kvant (Quantum) radar.

SM-12PM

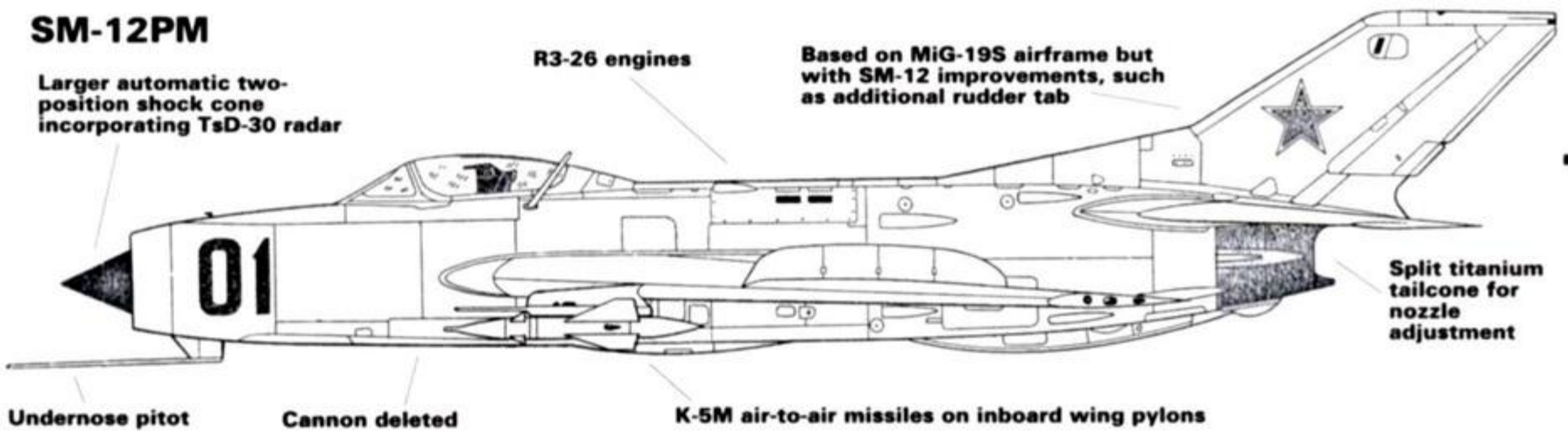
Like the 'basic' SM-12, this experimental aircraft built in 1957 was powered by Sorokin R3-26 turbojets. The SM-12PM (PM = *perekhvatchik modernizeerovannyy* – interceptor, upgraded) was an all-weather interceptor with improved armament and aerodynamics. The aircraft featured a new air intake with an automatically adjusted two-position centrebody. This gave a major increase in speed with no adverse effect on stability, controllability, range and endurance.

The sharp-lipped air intake was similar to that of the original SM-12 but its diameter was much bigger. So was the diameter of the dielectric shock cone housing the new TsD-30 radar. The shape and positions of the shock cone were carefully selected. The SM-12PM had a split titanium tailcone which could open up, the sections acting like convergent-divergent nozzle segments.

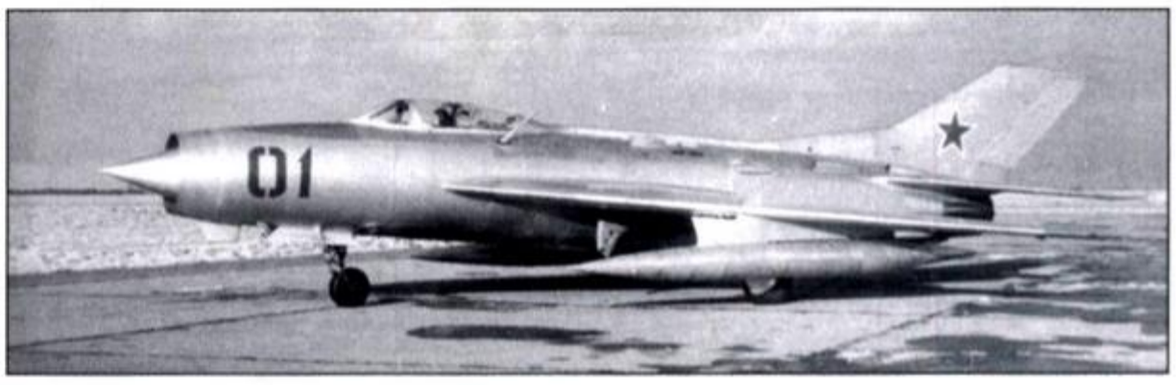
The guns were deleted; the armament consisted of two RS-2-U (K-5) AAMs. In addition to the radar, the aircraft had a new PKU optical sight.

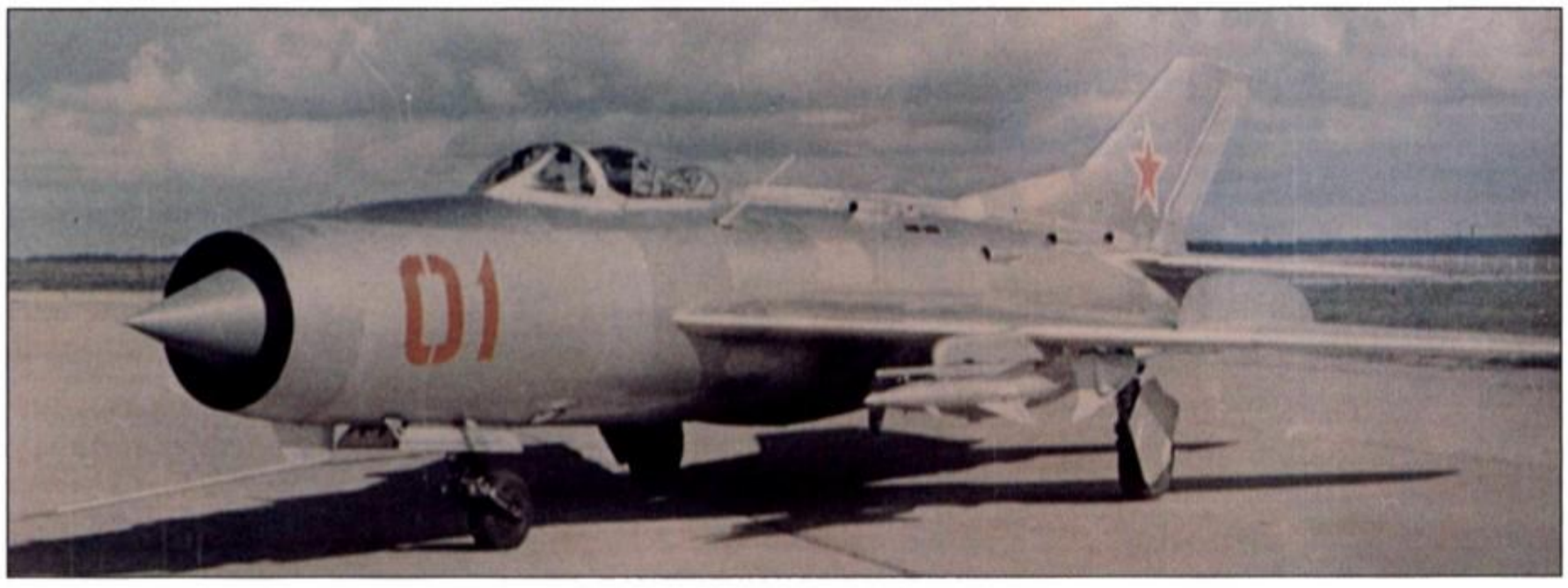
After the factory test stage was completed in 1958 the SM-12PM commenced state acceptance trials, which continued into 1959. Top speed was 1720 km/h (1,068 mph), and service ceiling was 17400 m (57,086 ft). The aircraft climbed to 10000 m (32,808 ft) in four minutes and had a range of 1700 km (1,055 miles) without drop tanks. The SM-12PM was also tested with non-standard 520-litre (114-Imp gal) drop tanks.

Experience gained with the SM-12PM allowed sharp-lipped air intakes to be used on later production fighters and proved valuable when designing the Ye-7 (an experimental version of the MiG-21, a sort of intermediate step from the MiG-21F-13 to the MiG-21PF 'Fishbed-B').


SM-12PM
Larger automatic two-position shock cone incorporating TsD-30 radar
R3-26 engines
Based on MiG-19S airframe but with SM-12 improvements, such as additional rudder tab
Split titanium tailcone for nozzle adjustment
Undernose pitot
Cannon deleted
K-5M air-to-air missiles on inboard wing pylons

The SM-12PM tested new supersonic fuel tanks. These were angled downwards to ensure clean separation when jettisoned.





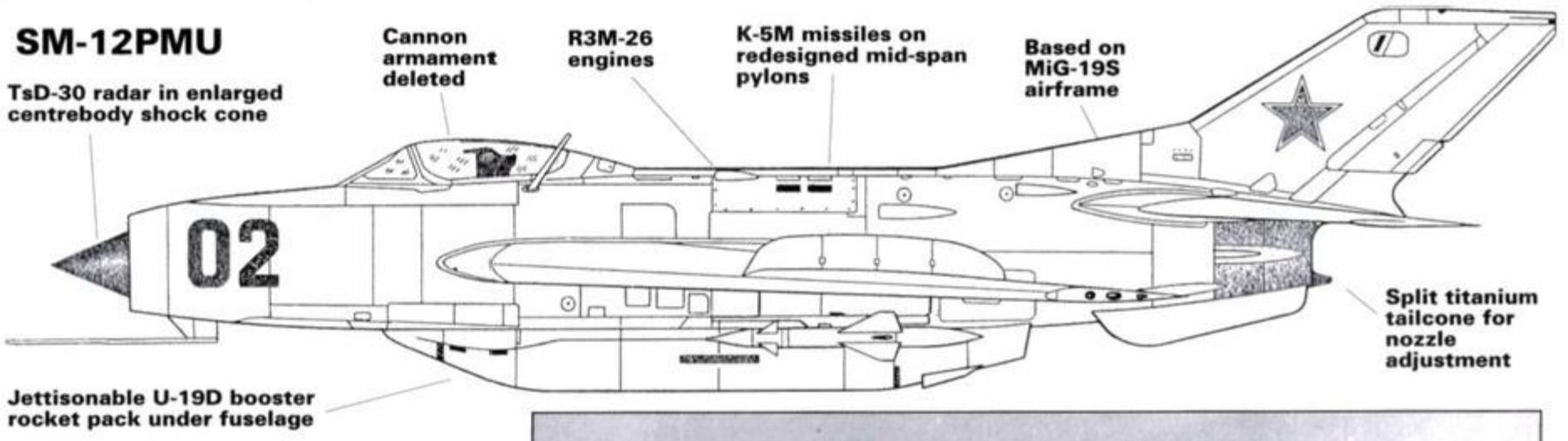
The SM-12PM was a logical next step from the SM-12, incorporating radar and missile armament. The intake geometry was similar to that later employed on the second generation of MiG-21s.

SM-12PMU

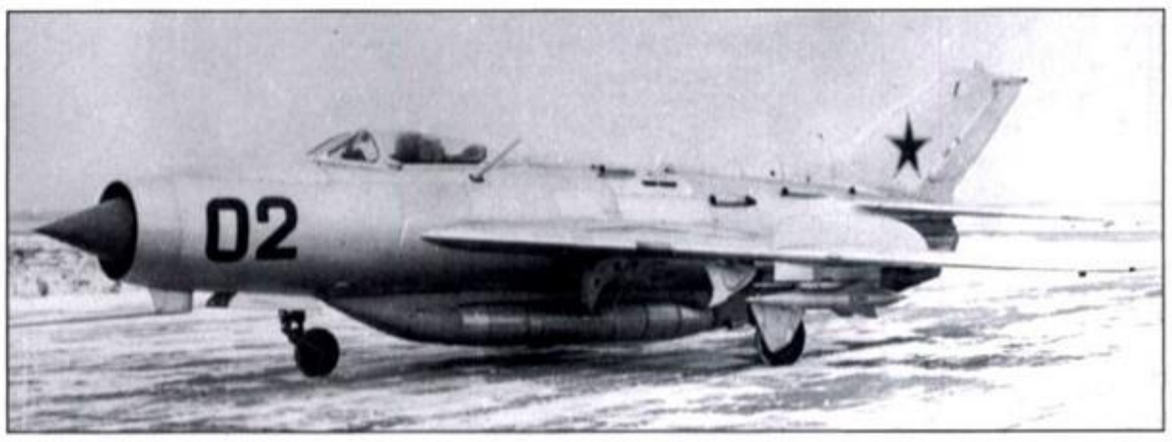
The second prototype of the SM-12PM was completed in 1958 as the SM-12PMU (U = *ooskoreetel* – rocket booster). It had a combined powerplant comprising two R3M-26 turbojets rated at 37.27 kN (8,377 lb st) in full afterburner and a U-19D liquid-fuel rocket booster rated at 39.23 kN (8,818 lb st). The booster installation was identical to that of the SM-51P/SM-52P; like these two aircraft, the SM-12PMU was used to test it.

The SM-12PMU was part of the SM-12-51 weapons system developed for countering enemy bombers in VFR and IFR conditions. It comprised the aircraft, the improved RS-2-US (K-5M) AAM and the Vozdookh-1 (Air) ground guidance system. The missile pylons were reshaped and relocated as compared to the SM-12PM. Tests revealed that the aircraft had a top speed identical to that of the SM-12PM (1720 km/h; 1,068 mph, or Mach 1.69) and a ceiling identical to that of the SM-50 (24,000 m/78,740 ft in a zoom climb).

During the state acceptance trials the SM-12PMU acted as an avionics testbed for the Lazoor command link system, the SOD-57M decimetre-waveband IFF set and the new RV-U radio altimeter operating in the 0-800 m (0-2,624 ft) AGL range. The radar and other avionics tested on the SM-12PMU were later fitted to production fighters.


SM-12PMU
TsD-30 radar in enlarged centrebody shock cone
Cannon armament deleted
R3M-26 engines
K-5M missiles on redesigned mid-span pylons
Based on MiG-19S airframe
Split titanium tailcone for nozzle adjustment
Jettisonable U-19D booster rocket pack under fuselage

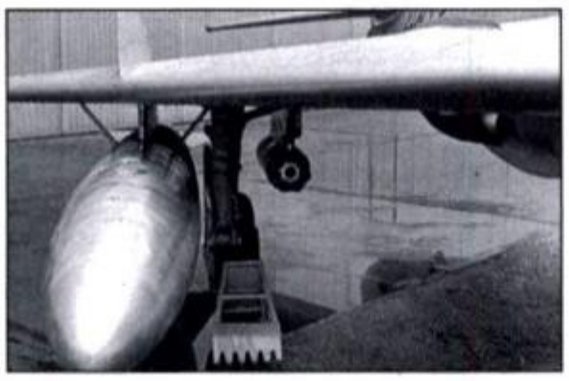
The SM-12PMU represented the ultimate expression of the MiG-19 design. Rocket-boosted for extreme altitude performance, it sported a capable weapon system which later became a feature of production fighters.



Foreign production

Avia S.105

The MiG-19S was built under licence by the Aero factory at Vodochody in Czechoslovakia as the S.105. Only the airframes were Czech-built, all other components being shipped in from the Soviet Union. The first S.105 flew in 1958, and production ended in 1961. All S.105s were consumed by the Czech air force, and differed in minor detail from the MiG-19S, chiefly by the addition of extra afterburner cooling inlets around the rear fuselage.



This close-up of a Czech S.105 shows the ORO-57K rocket launcher.

A landing S.105 displays the perforated ventral airbrake which augmented the two mounted either side of the rear fuselage.

Shenyang J-6 (MiG-19P)

Having successfully established a production line for the MiG-17F (as the Shenyang J-5), China naturally assessed the MiG-19 as a candidate for further licence production, intended to provide a supersonic interceptor for the PLA Air Force. Selected for production under China's second Five-Year Plan, the MiG-19 programme was assigned to the Shenyang Aircraft Factory, which produced its own tooling and design drawings. The agreement between China and the Soviet Union was signed in January 1958. Initially the radar-equipped MiG-19P was chosen, allocated the local designation J-6. Shenyang first assembled a handful of MiG-19Ps from Soviet-supplied kits, the first flying on 17 December 1958. On 30 September 1959 the first Chinese-built aircraft flew.

Initial production of MiG-19Ps amounted to little, and what few were built were not accepted due to poor quality control. Having established, with Soviet help, an effective jet aircraft industry, much of this ground was lost during the upheavals of the 'Great Leap Forward'.

Shenyang J-6B (MiG-19PM)

In addition to Shenyang, a second source of J-6s was established at the Nanchang Aircraft Factory, previously responsible primarily for the piston-engined CJ-5/6 (based on the Yak-18 trainer). Nanchang's first of seven kit-built MiG-19Ps flew on 28 September 1959, followed by five MiG-19PM kits. These were designated J-6B. Another 19 J-6Bs were believed to have been built from new at the factory although these, like the output from Shenyang, was severely affected by poor build quality. Several MiG-19P/PM equivalents are believed to have been built in later production although these may have been rebuilds of the original batch. Experience with the MiG-19P/PM gave Nanchang the platform for design and development of the Q-5 attack aircraft, which although superficially appears to be a MiG-19 in all but forward fuselage, in fact shares only the rear fuselage and undercarriage with the Soviet-designed fighter.

Shenyang J-6/F-6 (MiG-19S)

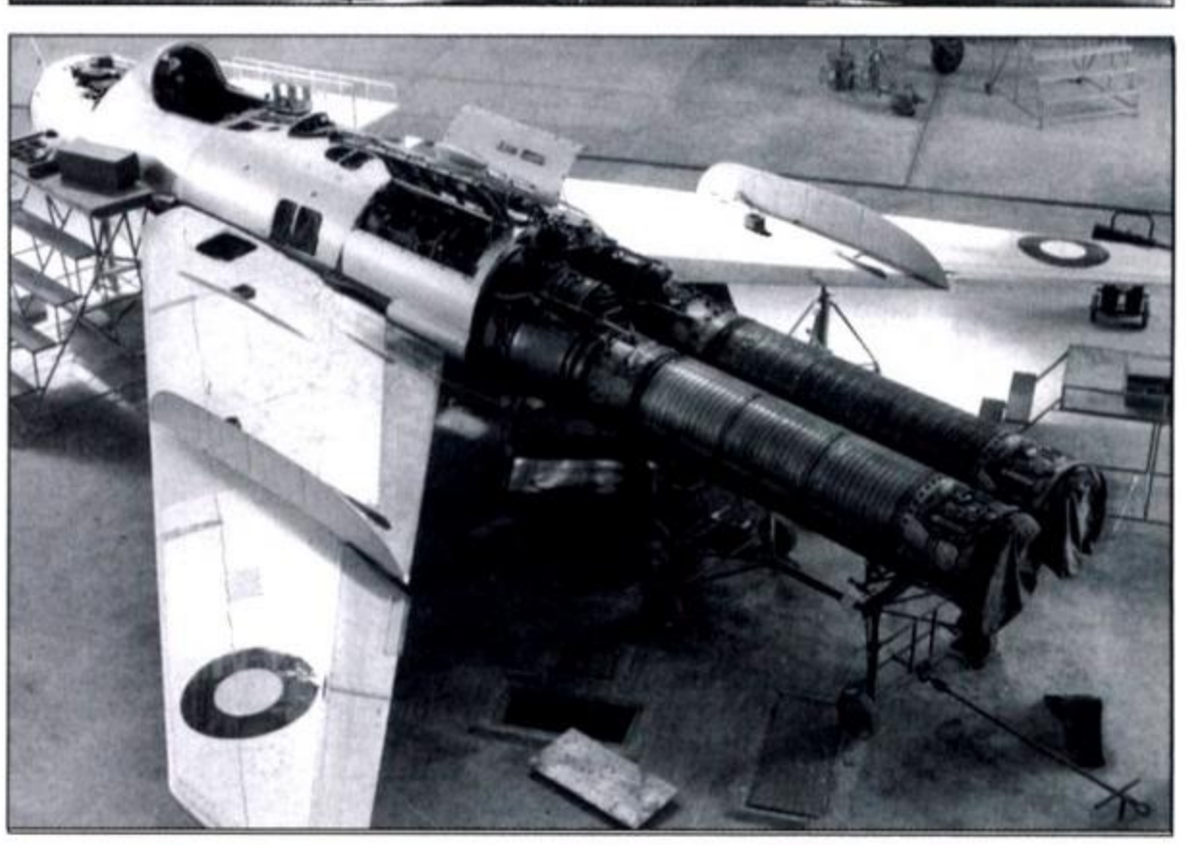
For the Chinese aviation industry the 'Great Leap Forward' was anything but, and in its aftermath the J-6 programme was left in tatters. In 1961 it virtually began anew, this time using Soviet-supplied drawings and rebuilt tooling. Instead of radar-equipped aircraft, Shenyang now produced the basic MiG-19S day fighter, although the J-6 designation remained the same. It is believed that several were supplied in kit form from Soviet production.

Power was provided by the Wopen-6 turbojet, a copy of the Tumanskii RD-9BF-811 delivering 25.49 kN (5,730 lb) thrust dry and 31.87 kN (7,165 lb) with afterburning. Powerplant production was initially undertaken by Shenyang, but was later entrusted to the Liming (LM) factory. Armament remained the same as the Soviet-built aircraft, namely three NR-30 cannon (built by Norinco) and four weapon pylons for various bombs (up to 250 kg)

Below: The J-6 rapidly became the PLAAF's main day fighter, while also being supplied to the PLA Navy. This scene shows an aircraft receiving maintenance: the removed rear fuselage is next to the hangar.

Right: J-6s take shape in the Shenyang factory. Despite all of the problems associated with political changes, J-6 production accounted for a greater number of aircraft than the Soviet factories.

Below: Well-worn, this F-6 carries the badge of No. 19 Sqn, PAF. It is from the first batch delivered, and probably saw action in the 1971 war with India.



Right: An F-6 in the PAF's major rework facility at Kamra is fully 'unbuttoned'. The entire rear fuselage could be removed for access to the engines and jetpipes.

rocket pods and drop tanks.

The first of the new-batch J-6s flew in December 1961 and was certificated for PLAAF use two years later. During 1964-66 large numbers of well-built aircraft entered service, including many for the PLA Navy, which used the type for anti-shipping attack duties. However, the J-6 programme suffered another huge political setback in the 'Cultural Revolution' which again had a devastating effect on the production rate and quality.

In the early 1970s production was slowly restored to its former rate and quality and lasted into the 1980s, reaching around 3,000 aircraft. Substantial numbers were exported under the Westernised designation F-6, recipients including Albania, Bangladesh, Egypt, Iran, Iraq, North Korea, Pakistan, Somalia, Tanzania, Vietnam and Zambia. Of these, Pakistan's aircraft were the most notable for the high degree of Western equipment incorporated into them through a series of upgrades. Among the modifications were the fitment of Martin-Baker Mk 10 ejection seats, new avionics and the addition of AIM-9 Sidewinder-capable outer wing launch pylons. Pakistani F-6s could also carry a large semi-conformal belly tank.

Pakistan's first batch comprised 74 aircraft rapidly supplied from Chinese stocks, three squadrons being operational before the end of 1966, thanks to initial Chinese training. These fought in the war with India in 1971, following which two batches, each of 60 F-6s, were supplied (in 1972 and 1977). In 1980 two-seat FT-6s followed. Numbers of F-6s still figure in the PAF order of battle in the late 1990s.

Two nations which still operated F-6s in the 1990s are Albania (above) and Egypt (right). The Albanian aircraft are early machines, lacking the tail-base chute.

Shenyang J-6C

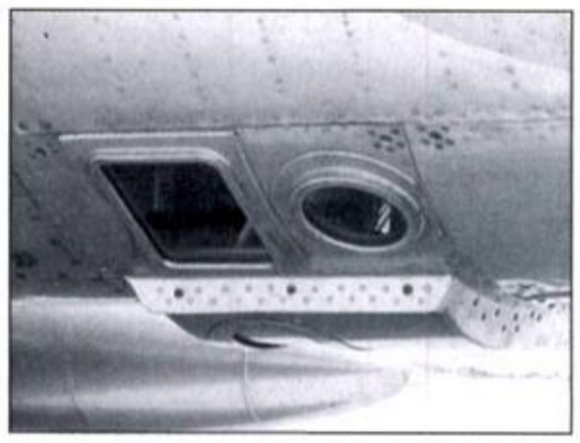
The J-6C differed little from the MiG-19S-based J-6, the primary difference being the relocation of the brake chute to a bullet fairing at the base of the fin. Many of the F-6 export aircraft, including the second and third batches of those delivered to Pakistan, were to this standard.

Seen undergoing maintenance, this Pakistani F-6 sports the tail-base brake chute which characterised the J-6C version.

Shenyang JZ-6

From about 1967 some J-6s were completed or converted as low/medium-level reconnaissance platforms, with a battery of cameras carried in the lower forward fuselage. Designated JZ-6 to signify their dual tasking, the aircraft retained the wingroot cannon but the fuselage cannon was deleted. In the early 1970s at least three JZ-6s were modified for high-altitude reconnaissance, and in early 1976 construction began on a new JZ-6 version which featured both infra-red and optical sensors.

This JZ-6 defected to Taiwan in 1977, allowing the West a close look at the aircraft's reconnaissance installation. Apart from this the aircraft is identical to a standard J-6.



The tactical reconnaissance JZ-6 carries a battery of cameras in the lower forward fuselage, with windows peering obliquely and downwards. The fitment of the camera pack requires the removal of the nose cannon.

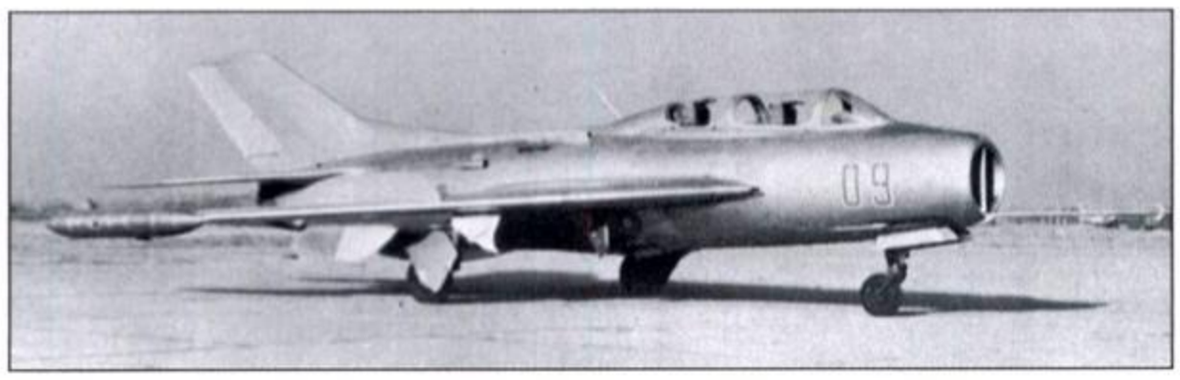
Shenyang JJ-6 (FT-6)

A manifestation of the restoration of stability for the aircraft industry after the 'Cultural Revolution' was the production by Shenyang of the JJ-6 two-seat trainer, which first flew on 6 November 1970, but the certification of which was delayed until December 1973. Despite some evidence to the contrary, Mikoyan is believed to have never built a two-seat 'MiG-19UTI', conversion to the MiG-19 fighter from the MiG-15UTI not being judged to be a problem. By the 1970s, however, flight safety considerations had assumed greater importance, and China felt that a trainer with handling characteristics similar to the J-6 was essential. This view was reinforced by significant export orders.

The fuselage was stretched by some 84 cm (33 in) ahead of the wing, and the wingroot-mounted cannon were deleted to make room for extra fuel, restoring fuel capacity to within 150 litres (33 Imp gal) of the single-seater. A single cannon was usually retained below the fuselage. Two ventral fins were added below the rear fuselage to maintain stability.

The JJ-6 was based on the airframe of the later J-6C with the relocated brake-chute fairing, tubeless tyres, and disc brakes on the main undercarriage units. The type also had nosewheel braking and various new avionics systems.

Production of the JJ-6 totalled 634 examples, and many were exported under the designation FT-6 to serve as conversion and continuation trainers for the J-6/F-6 and Q-5/A-5. In Pakistan, which received a batch in 1980, surviving FT-6s were extensively upgraded (to the same standards as that nation's F-6 fighters) with Martin-Baker Mk 10L rocket-powered ejection seats. The zero-zero capability offered by this seat was a quantum leap from the 260 m (853 ft)/350 km/h (218 mph) minima of the original Shenyang seat. Using the 'lower-slung' Martin-Baker seat, pilots whose height exceeds 1.73 m (5 ft 8 in) can at last wear a proper flying helmet. JJ-6 trainers also remain in service in Bangladesh, China and North Korea.



Above: This Egyptian FT-6 provides detail of the canopy hinging and nose cannon.

Left: This early JJ-6 (possibly one of the prototypes) sports unidentified wingtip pods.

Below: A single-seat F-6 peels away from an FT-6 of Pakistan's No. 25 Squadron, which acts as the OCU.

Shenyang J-6III

Subject of some confusion, the J-6III was developed to increase the basic performance of the day fighter J-6. The most obvious feature was a needle-shaped centrebody in the intake, which gave rise to speculation that this was a radar-equipped fighter. In fact, the centrebody served only an aerodynamic purpose, being a variable shock cone to extract better performance from the uprated engines fitted to the type. These were the Wopen WP6A turbojets (as used by the Q-5) which each delivered 29.42 kN (6,614 lb) thrust dry and 36.78 kN (8,267 lb) with afterburning. Aerodynamic modifications were notable, including cropped wings with increased-chord ailerons and flaps to compensate for the corresponding reduction of roll authority and low-speed lift.

The J-6III (also erroneously reported as the J-6Xin) was developed from early 1969 and first flew on 6 August. It was plagued by the problems associated with the 'Cultural Revolution', notably bad quality, and while it flew, turned and climbed much faster than the standard J-6, it suffered from handling problems. Several hundred were believed to have been built, virtually all having to be rebuilt in a major programme prior to delivery to the air force.

This J-6III is on display at the Chinese air force museum outside Beijing. The intake shock cone was accompanied by cropped wings and uprated engines to improve the basic J-6's performance.

Shenyang (Guizhou) J-6A (J-6IV)

The final Chinese variant was the J-6A (possibly also J-6IV), which was a radar-equipped version developed by Guizhou. This differed from the MiG-19P/PM by having a more bulbous upper intake lip radome and a more pointed intake centrebody radome. It was compatible with the PL-2 missile, a Chinese-built version of the R-3 (AA-2 'Atoll' – itself a reverse-engineered copy of the AIM-9B). The J-6A featured the fin-base brake chute fairing of the J-6C. Only limited numbers appear to have been built, having received certification in 1976.

Martin-Baker's M.B.5 was another aircraft often described as 'the best piston-engined fighter ever', but one with a stronger claim than most. Everything about the aircraft was 'right' from the start, but it was overlooked by the UK aviation establishment as it did not come from a recognised manufacturer. In addition to its outstanding performance, the aircraft was an engineering marvel. A post-war A&AEE report remarked that, among other glowing tributes, "The general design and layout of this aircraft is excellent and is greatly superior from the engineering and maintenance aspect to any other similar type of aircraft."

Martin-Baker fighters

Son of an Ulster farmer, Jimmy Martin had virtually no formal education. He just happened to be a very exceptional man. Not one to work for others, he set up in business – undeterred by having almost no money – and eventually became Sir James Martin CBE, famed for ejection seats which today save aviators' lives all over the world. But, at least initially, he really wanted to create superior aircraft.

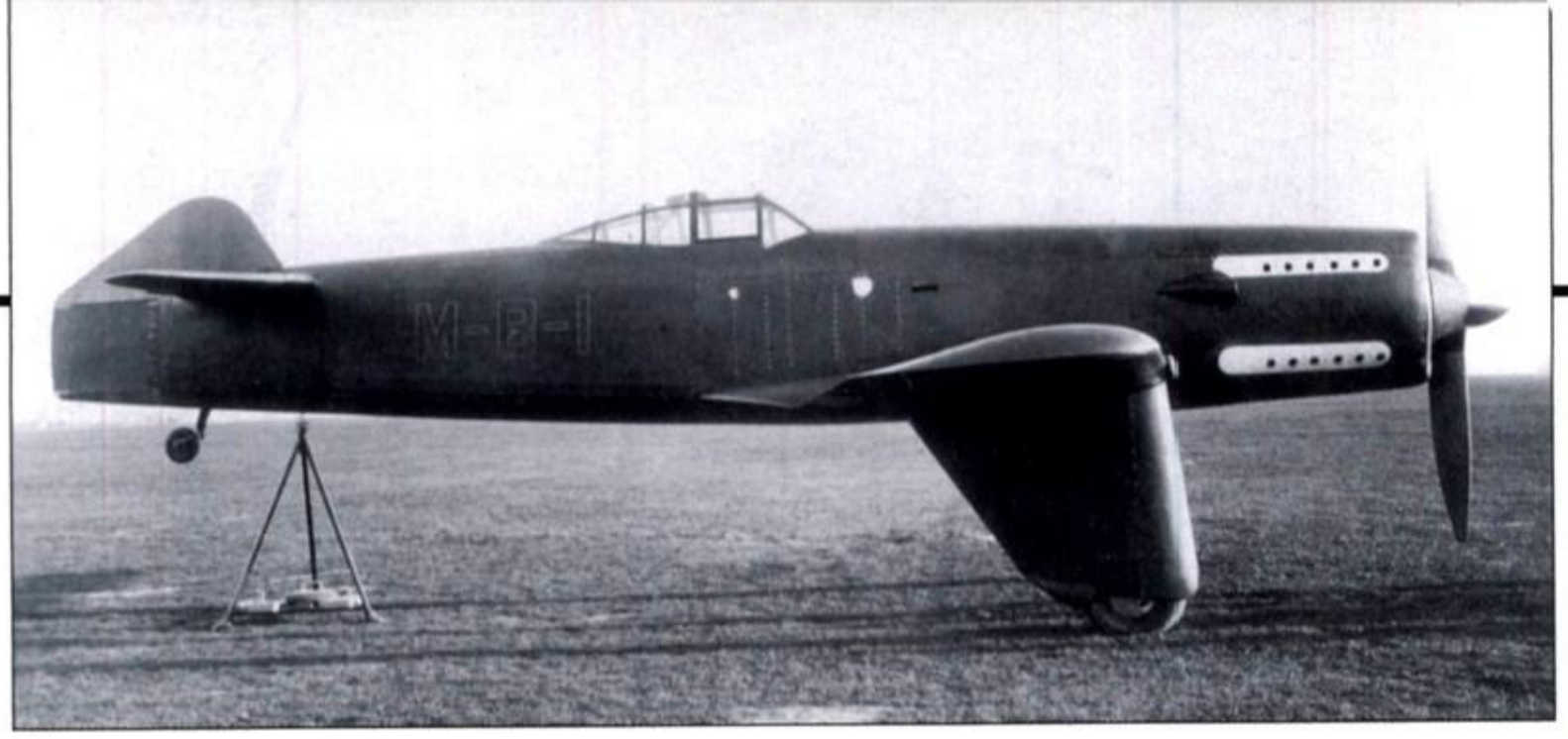
In 1929 Martin took his two employees out of a small jobbing workshop in Acton, in west London, and set up Martin's Aircraft Works in a hangar and a ramshackle collection of ancient army huts at Denham, a few miles further west. Here they designed a two-seat aerobatic aircraft with the engine in the mid-fuselage driving the nose propeller via a long shaft, as in the P-39 Airacobra. Sadly, they had no money with which to build it.

In 1934 Martin was joined by Captain Valentine Baker, MC, AFC and, assisted financially by Mr Francis Francis, they formed Martin-Baker Aircraft. They built a neat two-seat cabin monoplane of conventional layout, the M.B.1. Napier lent the 160-hp (119-kW) Javelin engine. Painted black and registered G-ADCS, this aircraft was taken to nearby Northolt and flown very successfully by Baker in March 1935.

A key feature of the M.B.1 was a patented form of construction based on thin-walled steel tubing. These tubes were cut by a hacksaw and joined by brazing, welding or various kinds of bolts. Martin wanted to use this construction to build a fighter. He was undeterred by such trivialities as near-total absence of money, or lack of experience, or the undoubted fact that the RAF bought aircraft only from a 'closed shop' of established British firms. Single-handedly, he was to design a succession of powerful fighters.

By dogged persistence he learned that the Air Ministry had decided that future fighters had to have eight machine-guns, and he also managed to read the related F.5/34 specification. He had no chance of getting a contract, but he did eventually receive on Ministry embodiment

Martin-Baker's first product was this low-wing two-seat cabin monoplane, the M.B.1. Seen here at Northolt, the aircraft first flew in early 1935, at which time this layout was still regarded as a novelty. The M.B.1 introduced James Martin's new steel-tube construction. It was lost in a hangar fire at Denham in 1938.



The M.B.2 fighter originally flew with no vertical tail surfaces, but was soon given a vestigial fin, as seen here, although it retained the unusual rudder which was attached to the sternpost of the rear fuselage. On the power of its 24-cylinder 'H' inline Napier-Halford Dagger M.3, which never delivered more than 800 hp (597 kW), the M.B.2 could achieve a creditable 320 mph (515 km/h) in level flight with full eight-gun armament and ammunition installed. Martin designed retractable undercarriage but it was never tested.

loan a fine two-bladed wooden propeller, a Napier Dagger 24-cylinder air-cooled engine (which actually gave about 200 hp/149 kW less than the alleged 1,020 hp/761 kW) and, believe it or not, eight real 0.303-in (7.7-mm) Browning machine-guns from the very first batch made under licence in England in 1937.

Structurally, the M.B.2 resembled a much stronger version of the M.B.1. As before, the entire design was tailored to easy disassembly and simple maintenance. The stubby wings had the same three tubular spars forming a triangular girder, but with the outer wings able to be unbolted in a few minutes. Aft of the spar the covering was fabric, as it was over the control surfaces and most of the fuselage. The main landing gears were fixed, and faired in slim trousers; the cockpit was enclosed under a canopy which hinged to the right like a Bf 109; the split flaps, gun circuits and extendible crash pylon were operated by a low-pressure pneumatic system; and the long rear fuselage (length was greater than the span, amazing for the 1930s) served as the fin. Later, a small fin was added.

The armourer's friend

Even after it had been given a fin, the M.B.2 looked more like a sporting racer than a fighter. To discover its true qualities one had to go beyond first impressions. For example, despite the lack of a fin, a model tested in the Farnborough vertical spinning tunnel recovered from spins faster than any aircraft tested at that establishment up to that time. As for what the armourers thought, one recorded, "We could scarcely believe our good fortune in working on such a delightful machine. Everything had been made absurdly easy. There were four guns in each wing. I had no access doors to baffle me with exasperating locking buttons ... one turn of a handle and the whole upper surface of the wing stood on end, giving perfect access. A rubber-covered seat fitted along the rear of the gun bay brought luxury ... and eliminated the curve of the wing, to give a flat top for tools. Removal of the guns and magazines took five minutes instead of at least 50 on other fighters."

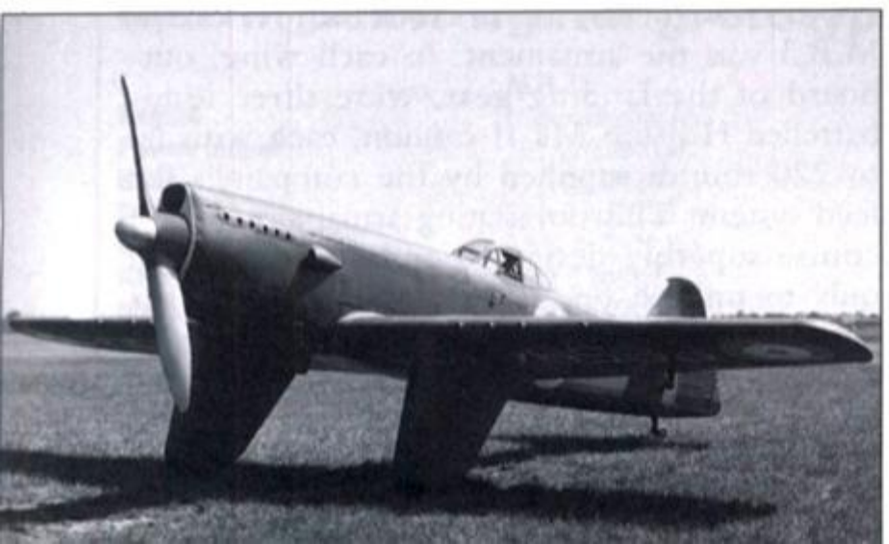
On 15 June 1937 the M.B.2 was registered as G-AEZD, but the completed aircraft, painted in an overall deep green colour, carried the SBAC registration M-B-1. Baker first flew it at Harwell, Berkshire, on 3 August 1938. He was generally delighted with its handling, but, predictably, directional stability was inadequate. The M.B.2 was accordingly given a small fin and a taller rudder.

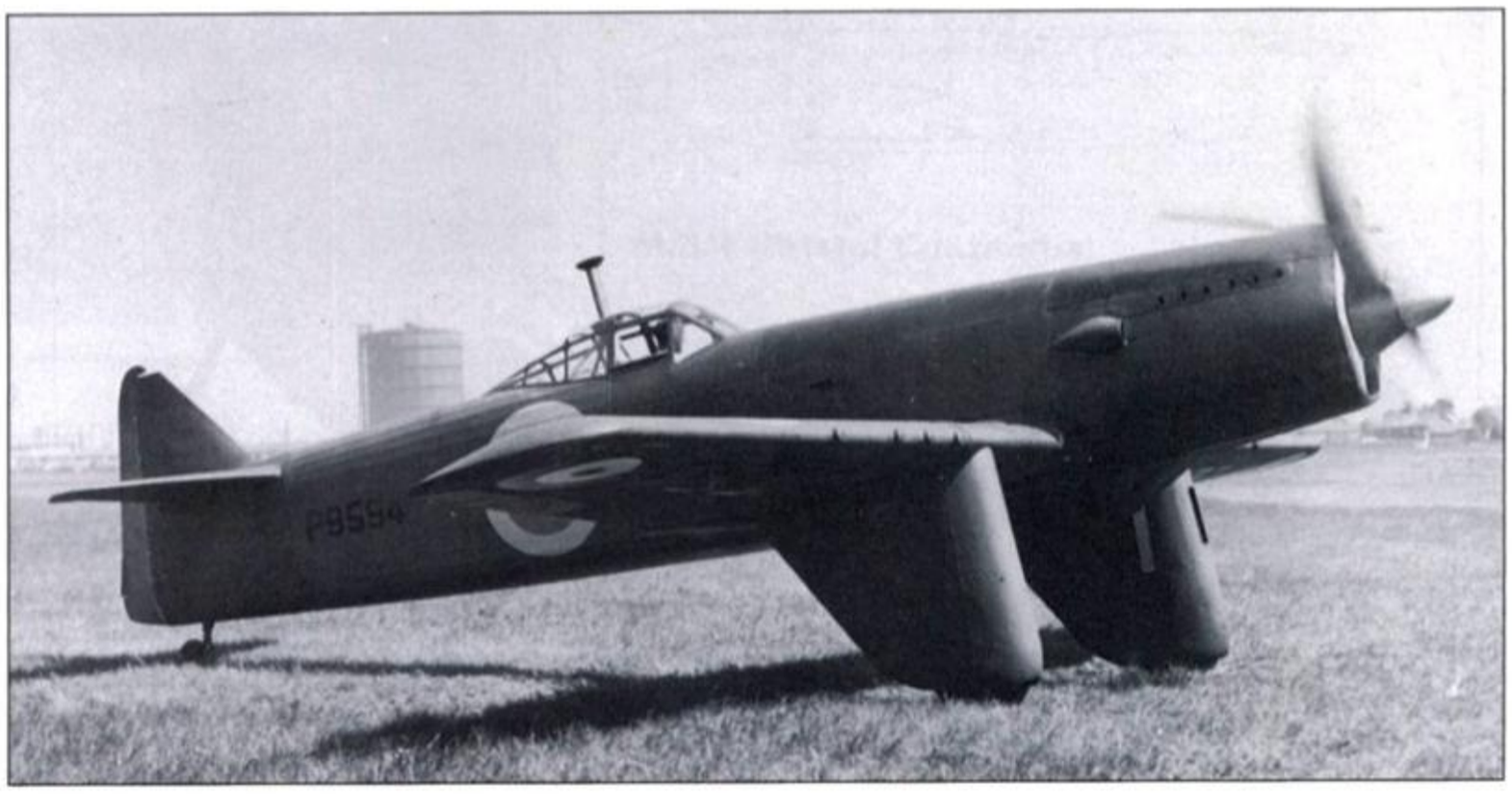
By 1939 it was wearing green and 'dark earth' camouflage, with yellow-bordered Type A.1 roundels and the serial P9594. RAF testing at Martlesham Heath confirmed a mix of good and bad features, as well as outstanding mechanical design for easy servicing. The faults could easily have been rectified, but it was simpler to do nothing, and thus avoid offending the established firms. Although the Air Ministry eventually bought the M.B.2 for £13,500, it had actually cost Martin nearly £45,000, almost breaking the little firm. The M.B.2 was dismantled during the war.

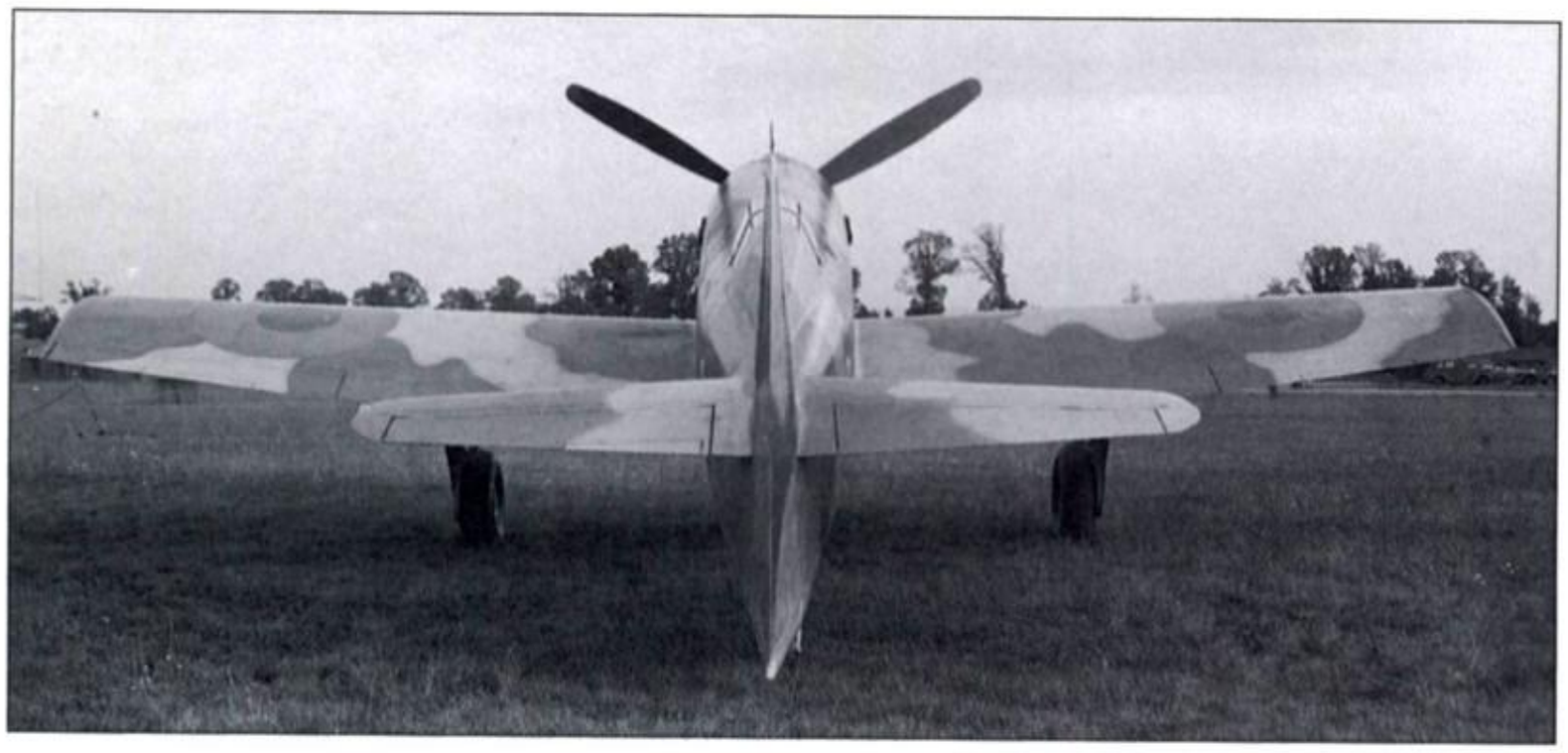
Design genius

As the country inexorably fumbled its way towards war, reluctantly rearming, Martin-Baker Aircraft began to receive Air Ministry contracts. At first they were small, and far between, but eventually became a torrent. All called forth Martin's design genius. Most were concerned with armament (exceptions were the cartridge-operated balloon-cable cutters along the leading edges of bomber wings), but in

In its final guise the M.B.2 was fitted with a conventional fin and rudder, finally alleviating any directional instability. Pilots remained ambivalent towards the fighter, while maintenance crew were overwhelmed by its brilliant simplicity and the ease with which it was worked on. Visible at right is the retractable, strut-braced crash pylon which deployed behind the pilot to protect him in the event of the aircraft turning over. The aircraft was dismantled at Denham some time during the war.







Above and left: Photographed shortly before its first flight, the M.B.3 exhibits the original 'razorback' configuration. The undercarriage had a phenomenally wide track – excellent for rough field operations – while the mainwheels were positioned so far forward that there was no danger of nosing over when running the engine at full throttle on the ground.

spare moments Martin never stopped drawing fighters. By 1939 he had a clear idea how to build the next, the M.B.3, and on 16 June of that year Martin-Baker signed a contract for three prototypes, to Specification F.18/39. The first, priced at £28,000, was to be ready on 15 December and the two others, priced at £18,000 each, by 15 February 1940.

Rolls-Royce offered Martin a ballasted Merlin for the M.B.3 pending delivery of the desired Griffon, but instead he was directed to use the greater power of the troublesome Sabre. The cowling was a masterpiece of sleek design.

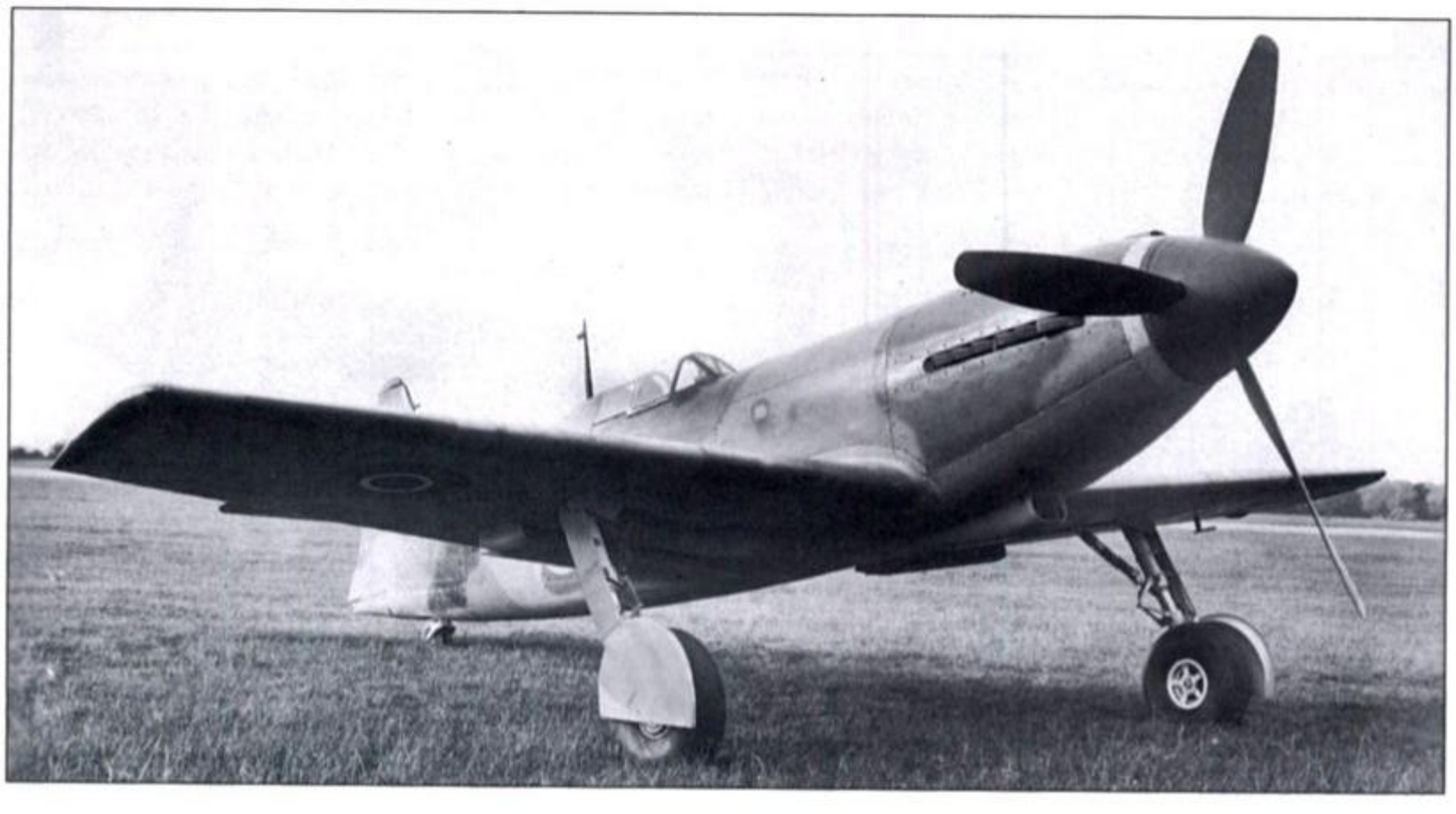
Not only was this contract harsh, and ridiculously underpriced, but its timing was sheer nonsense. It took no account of what actually happened. When war broke out in September 1939 the little firm ceased to get either machine tools or raw materials. Rolls-Royce failed to come up with the chosen Griffon engine, and to Martin's fury the Ministry told him to redesign the M.B.3 to take a Napier Sabre. Perhaps understandably, he distrusted this extremely complicated engine, with liquid cooling and 24 sleeve-valve cylinders. The extra weight of 740 lb (336 kg) in the nose demanded complete redesign of the whole aircraft. Despite this, a new contract, signed on 11 August 1940, reduced the price to £25,500 for the first M.B.3 and £17,000 for each of the other two.

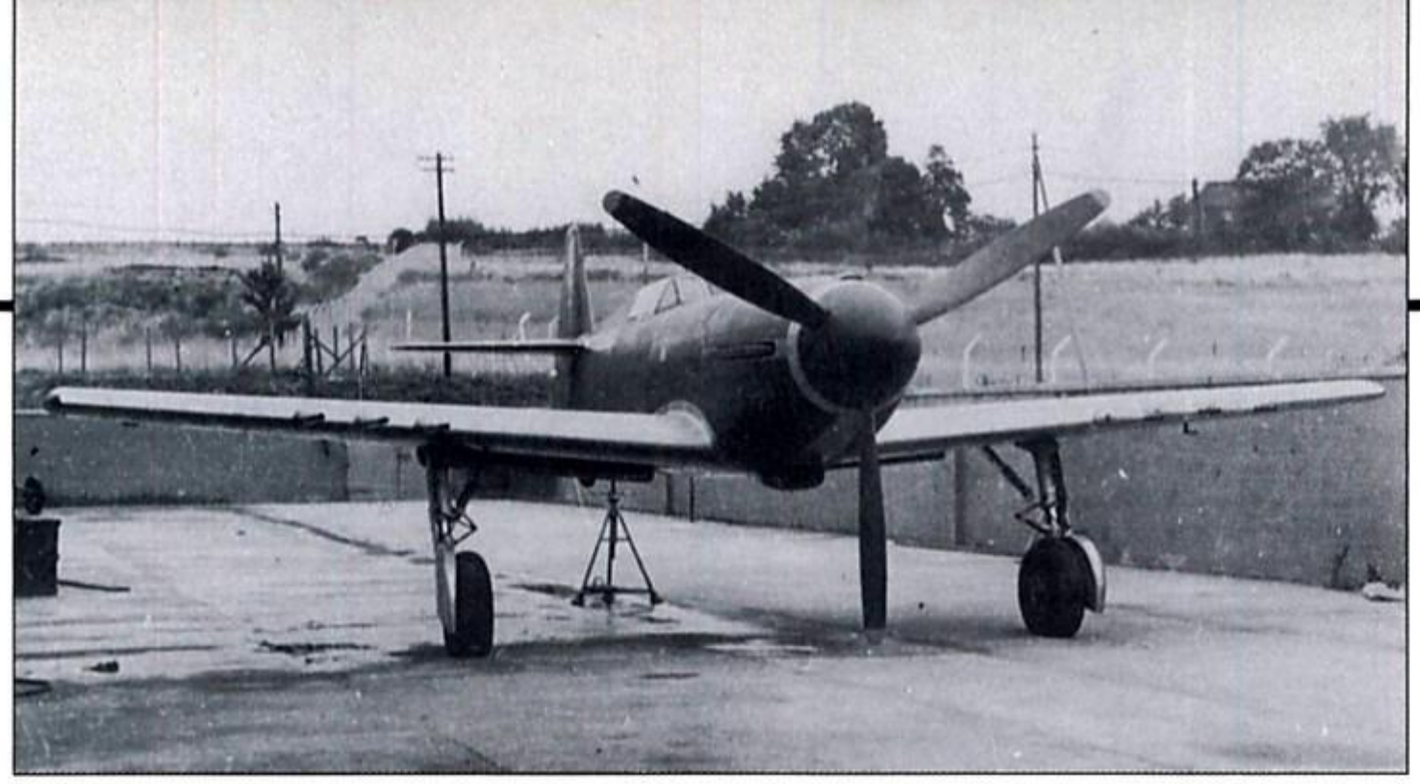
These prices bore no relationship to the cost of developing the M.B.3, which was several times greater. Although the fuselage retained a structural basis of steel tubes, assembled by flanged sleeves and fork fittings with tapered bolts, the wing was basically of Duralumin alloy, though with the simplest possible construction. The booms of the single main spar were laminated strips of high-tensile steel, their number reducing from root to tip. Almost all the covering of the airframe was flush-riveted stressed skin, though the rudder was covered in fabric. All control surfaces were driven by spring tabs.

Outstanding aircraft

The aircraft abounded with outstanding features. The 2,020-hp (1507-kW) Sabre II was tightly cowled and drove a three-bladed de Havilland Hydromatic propeller of 14 ft (4.27 m) diameter. The main landing gear had a track of 15 ft 5 in (4.7 m), just over double that of a Hurricane. Each wing had a large split flap, either fully up or fully down. Like the M.B.2, the secondary power system was pneumatic, operating at the low pressure of 60 psi (413 kPa). At the end of 1940, Martin-Baker designed a jettisonable sliding hood for the Spitfire, and eventually made over 60,000 for various fighters. A smaller version was fitted to the M.B.3, with a downward-hinged Spitfire-like door on the left.

Not least of the remarkable features of the M.B.3 was the armament. In each wing, outboard of the landing gear, were three long-barrelled Hispano Mk II cannon, each with up to 220 rounds supplied by the company's flat feed system. This devastating armament was of course superbly designed, and armourers had only to unlatch one large panel to expose the entire installation of three guns and their magazines. Despite this awesome firepower, and the fact that fuel capacity easily exceeded that of a





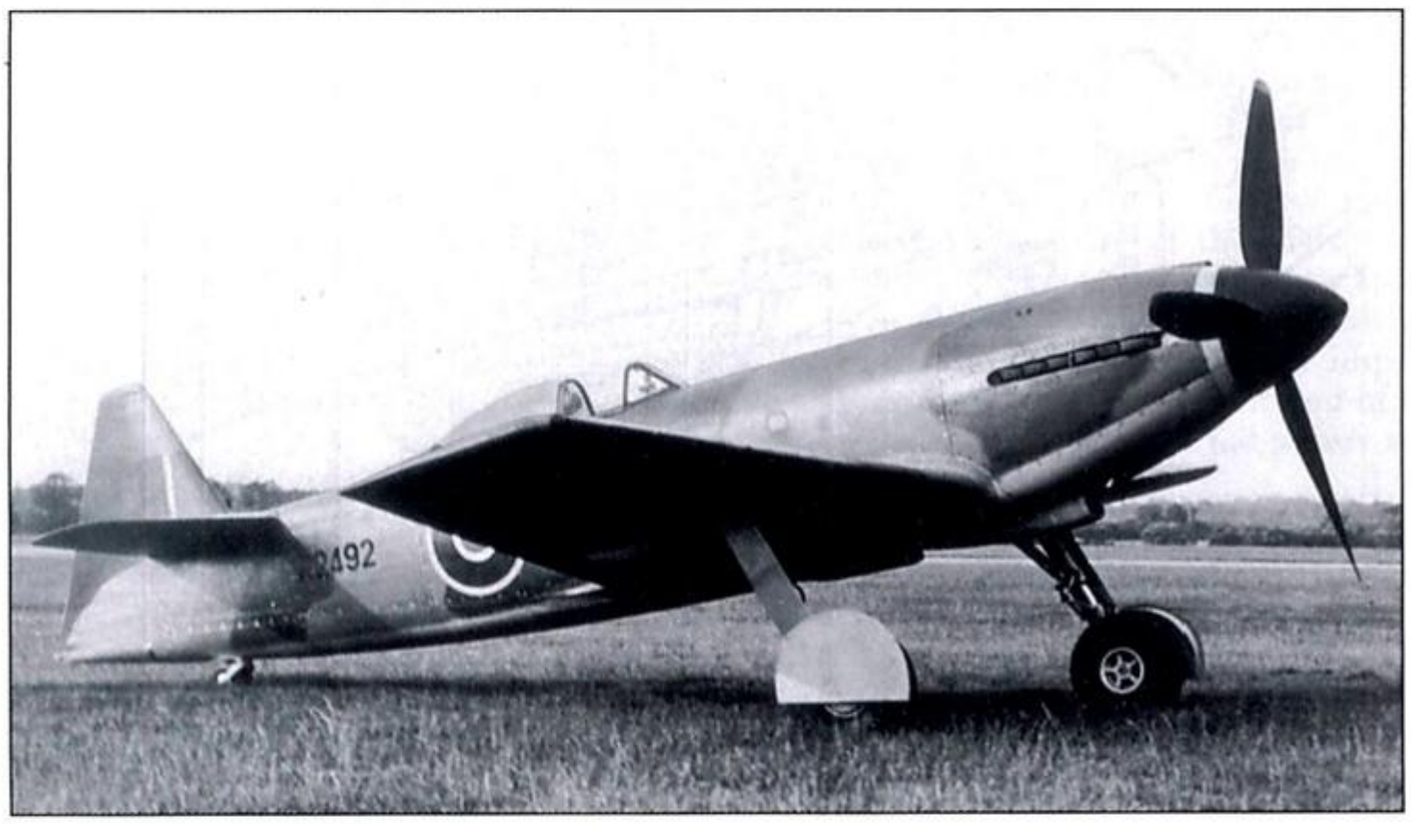
Above: The M.B.3 is seen at the Denham factory, having been fitted with the six 20-mm cannon (with 200 rpg) which were its intended armament. The wide, shallow radiators are noteworthy.

Right: A compact aircraft, the M.B.3 would have been agile and fast. A question mark hung over its structural integrity concerning the simultaneous firing of all six 20-mm cannon.

Typhoon, the M.B.3 was smaller than the Hawker fighter, and there is not the slightest doubt it would have had a considerably higher performance, probably similar to that of the later M.B.5.

Altogether, the M.B.3 was clearly outstanding, especially in its mechanical design and ease of servicing. On the other hand, it inevitably ran late. This was mainly because the original schedule had been wildly optimistic, the firm was tiny, and the sole designer could not resist repeatedly making improvements. As late as spring 1942 the cooling system was redesigned, with remarkable ducted radiators only 5 in (127 mm) deep under the wings. They were supplied by Delaney Gallay. The main radiator

Below: After its first flight on 31 August 1942, the M.B.3 was fitted with a teardrop canopy and a cut-down rear fuselage, one of the first aircraft to sport these features (which would become de rigueur *on fighters later in the war). The M.B.3's career was brought to an abrupt and tragic end on 12 September, when a sleeve-drive crank in the Sabre II engine broke, causing an immediate loss of power. RAF Wing, the Buckinghamshire airfield assigned by the Ministry for M.B.3 testing, was surrounded by small fields and trees, offering little chance for a successful forced landing. Attempting to land in a field, Captain 'Val' Baker hit a tree-stump, sending the M.B.3 cartwheeling. He died in the crash and the aircraft was written off.*

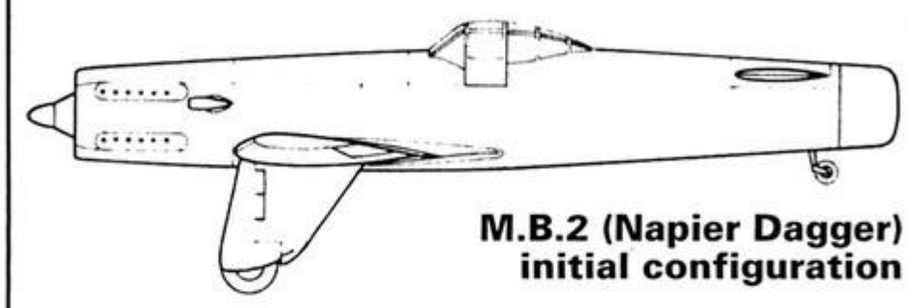


Martin-Baker fighter prototypes

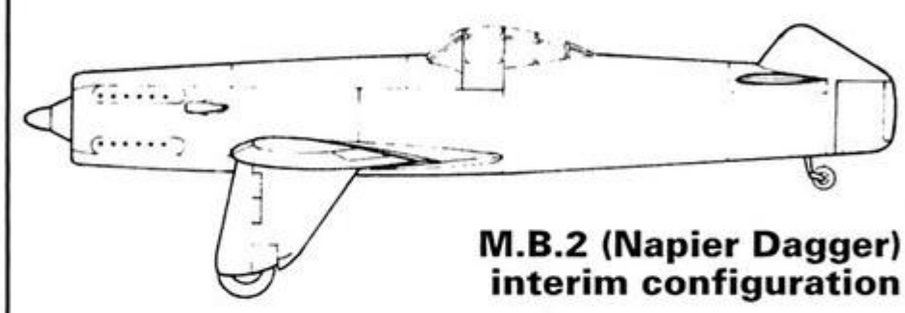
	M.B.2	M.B.3	M.B.5
Engine	Napier Dagger M.3	Napier Sabre II	RR Griffon 83
Power output	798 hp (598 kW)	2,020 hp (1515 kW)	2,305 hp (1728 kW)
Span	34 ft (10.36 m)	35 ft (10.67 m)	35 ft (10.67 m)
Length	34 ft 9 in (10.59 m)	35 ft 4 in (10.77 m)	37 ft 9⅛ in (11.51 m)
Gross weight	5,537 lb (2512 kg)	11,497 lb (5215 kg)	12,090 lb (5484 kg)
Armament	eight 0.303-in	six 20-mm	four 20-mm
Maximum speed	350 mph (563 km/h)	445 mph (716 km/h)	460 mph (740 km/h)
Service ceiling	29,000 ft (8839 m)	35,000 ft (10668 m)	40,000 ft (12192 m)
Maximum rate of climb	2,360 ft (719 m)/min	not measured	4,000 ft (1219 m)/min
Serial	P9594	R2492	R2496

Martin-Baker fighter development

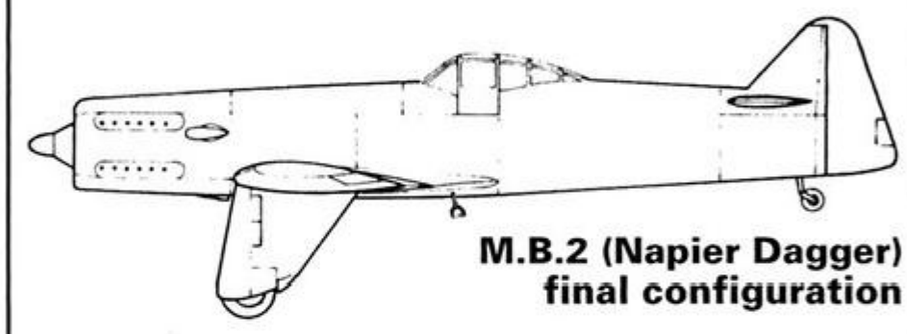
These Martin-Baker drawings show how the fighter family developed from the finless M.B.2 through to the ultimate M.B.5. The development of both the M.B.2 and M.B.5 was characterised by an increase in fin size. Martin had always intended the definitive fighter to be powered by the Griffon, but until the M.B.5 he was unable to obtain one. The M.B.3/3A/4 reflected the alternative powerplants available.



M.B.2 (Napier Dagger) initial configuration



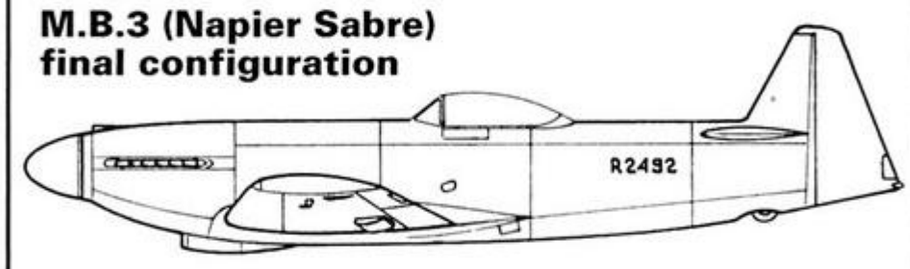
M.B.2 (Napier Dagger) interim configuration



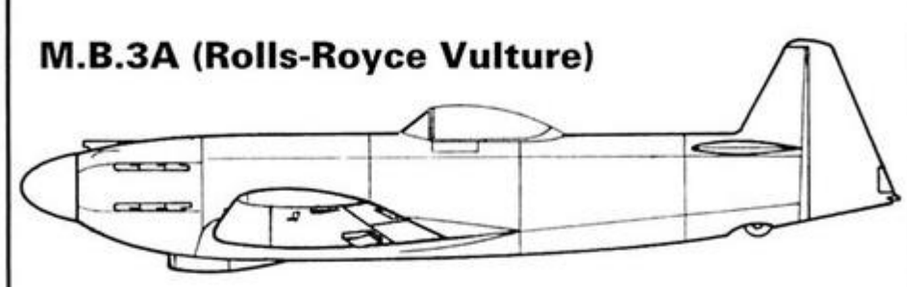
M.B.2 (Napier Dagger) final configuration

M.B.3 (Napier Sabre) initial configuration

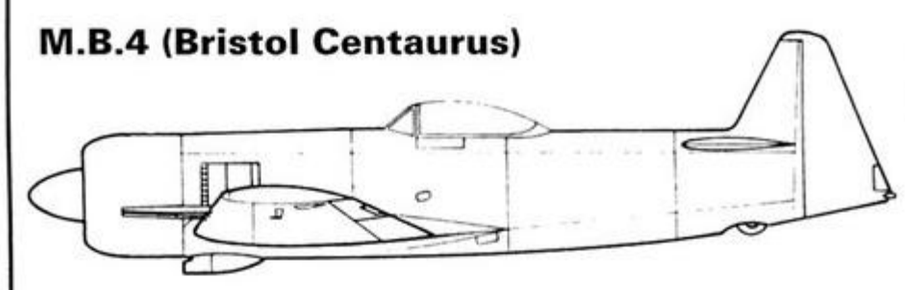
M.B.3 (Napier Sabre) final configuration



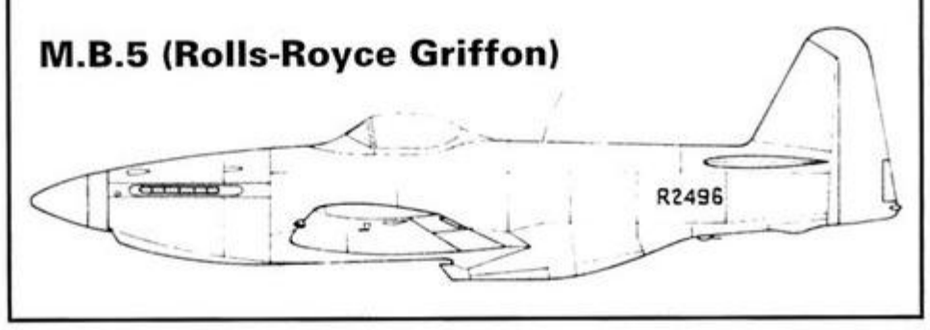
M.B.3A (Rolls-Royce Vulture)

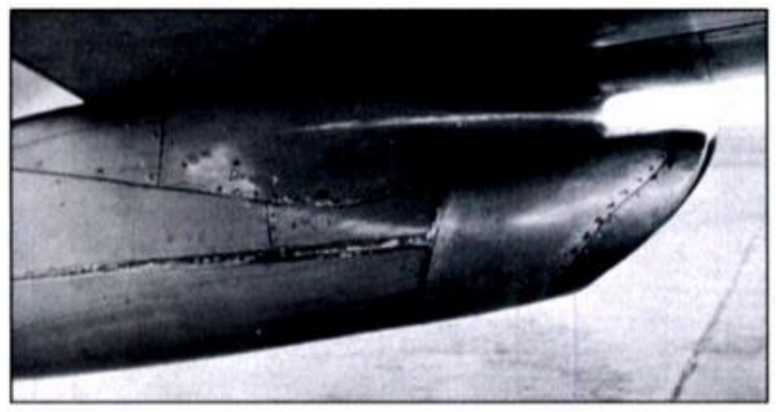


M.B.4 (Bristol Centaurus)



M.B.5 (Rolls-Royce Griffon)





Above: When it came to the design of the M.B.5's radiator, Martin was heavily influenced by the installation on the P-51 Mustang. The central duct had an ejector flap at the rear.

Left: After dallying briefly with a Vulture-powered (M.B.3A) and Centaurus-powered (M.B.4) version of his fighter, Martin received the Griffon. It was fitted into the much-modified second M.B.3 airframe to create the M.B.5. In its original guise, as seen here, it retained the small fin of its predecessor.

Martin-Baker M.B.5

1 Starboard elevator
2 Elevator horn balance
3 Tailplane construction
4 Elevator trim tab
5 Tail navigation light
6 Rudder servo tab
7 Rudder construction
8 Fabric rudder covering
9 Sternpost
10 Rudder horn balance
11 Tailfin construction
12 Port elevator trim tab
13 Port elevator
14 Elevator horn balance
15 Port tailplane
16 Fin root fillet
17 Tailplane centreline joint
18 Elevator hinge control
19 Tailplane attachment points
20 Rudder and elevator hinge control
21 Tailwheel doors
22 Tailwheel
23 Bridge support
24 Retraction strut
25 Tailwheel leg pivot point
26 Rear fuselage jacking points
27 Tailplane 'push-pull' rods
28 Steel tube fuselage girder construction
29 VHF aerial
30 Fuselage access panels
31 Tubular steel members bolted joints
32 Dorsal frames
33 Aluminium fuselage skinning
34 Whip aerial
35 Pneumatic system air bottle
36 Radio transmitter/receiver, TR.1464
37 Radiator air outlet duct
38 Radiator shutter door, open
39 Shutter door jack
40 Combined oil, coolant and intercooler radiators
41 Radiator attachment point
42 Wing trailing-edge root fillet
43 Radio equipment, R.3090
44 12-Volt, J5AH battery (one each side)
45 Pneumatic undercarriage retraction ram
46 Fuselage main longeron
47 Remote compass transmitter
48 Rear fuel tank, 130-Imp gal (591-litre) capacity
49 Fuselage access panel joint strip
50 Wingroot girder rib construction
51 Ventral radiator intake
52 Wing rib construction
53 Flap shroud construction
54 Split trailing-edge flap
55 Starboard gun bays
56 Hispano Mk II 20-mm cannon
57 Martin patent flat-belt ammunition feed mechanism
58 Ammunition boxes
59 Aileron servo tab
60 Starboard aileron construction
61 Aileron control links
62 Outer wing ribs
63 Wing-tip fairing
64 Starboard navigation light
65 Wing main spar
66 Leading-edge nose ribs
67 Cannon barrel fairings
68 Main undercarriage leg door
69 Shock absorber leg strut
70 Wheel fairing door
71 Dunlop pneumatic brakes
72 Starboard mainwheel
73 Undercarriage torque scissors
74 Retraction strut
75 Leading-edge stringers
76 Retraction strut pivot mounting
77 Main undercarriage wheel housing
78 Laminated steel spar boom
79 Leading-edge main torsion box
80 Main spar attachment point
81 Coolant pipe runs
82 Forward fuel tank, 70 Imp gal (318 litres)
83 Rudder pedals
84 Cockpit floor
85 Control column
86 Seat raising handle
87 Pilot's seat
88 Safety harness
89 Canopy rear decking
90 Sliding cockpit canopy cover
91 Windscreen panels
92 Gyro gunsight
93 Pilot's side console panel
94 Instrument panel shroud
95 Back of instrument panel
96 Oil tank, 14-Imp gal (64-litre) capacity
97 Oil tank support struts
98 Windscreen fairing panel
99 Port trailing-edge flap
100 Port gun bay
101 Port Hispano Mk II 20-mm cannon
102 Martin patent flat-belt ammunition feed mechanism
103 Ammunition boxes
104 Pitot tube
105 Aileron servo tab
106 Port aileron
107 Wingtip fairing

filled the space between the starboard landing-gear well and flap, while the oil cooler extended over a shorter span ahead of the port flap. It was all very well for the Ministry of Aircraft Production (MAP) to say, "The firm is doing itself the greatest disservice by its continued dilatoriness ...", but the tiny Martin-Baker team was working day and night.

By 1942 it was evident, at least to the MAP, that the M.B.3 would never go into production. The Ministry did not want to ruffle the feathers of the big firms, and in any case in wartime there was reluctance to switch over the work of a large factory. Instead, Martin's little firm was regarded as 'extremely useful in designing and producing gadgetry'. An excuse for dismissing the M.B.3 was that 'we shall not have enough Sabres for it'.

To see if anything else could be done, Martin and Baker investigated the possible use of the American Wright R-2160 Tornado engine. They also invited North American Aviation to consider licence production. The California firm studied the M.B.3 carefully, and suggested that many of its features 'warrant ... incorporation in all service aircraft', but concluded that the future Merlin-engined Mustang might have even better performance.

At last, in the summer of 1942, the first M.B.3 neared completion. It was finished in day fighter green/grey camouflage, with 1942 C-type roundels and fin flash, the prototype yellow 'P' in a circle and the serial number R2492.

Unsuitable test site

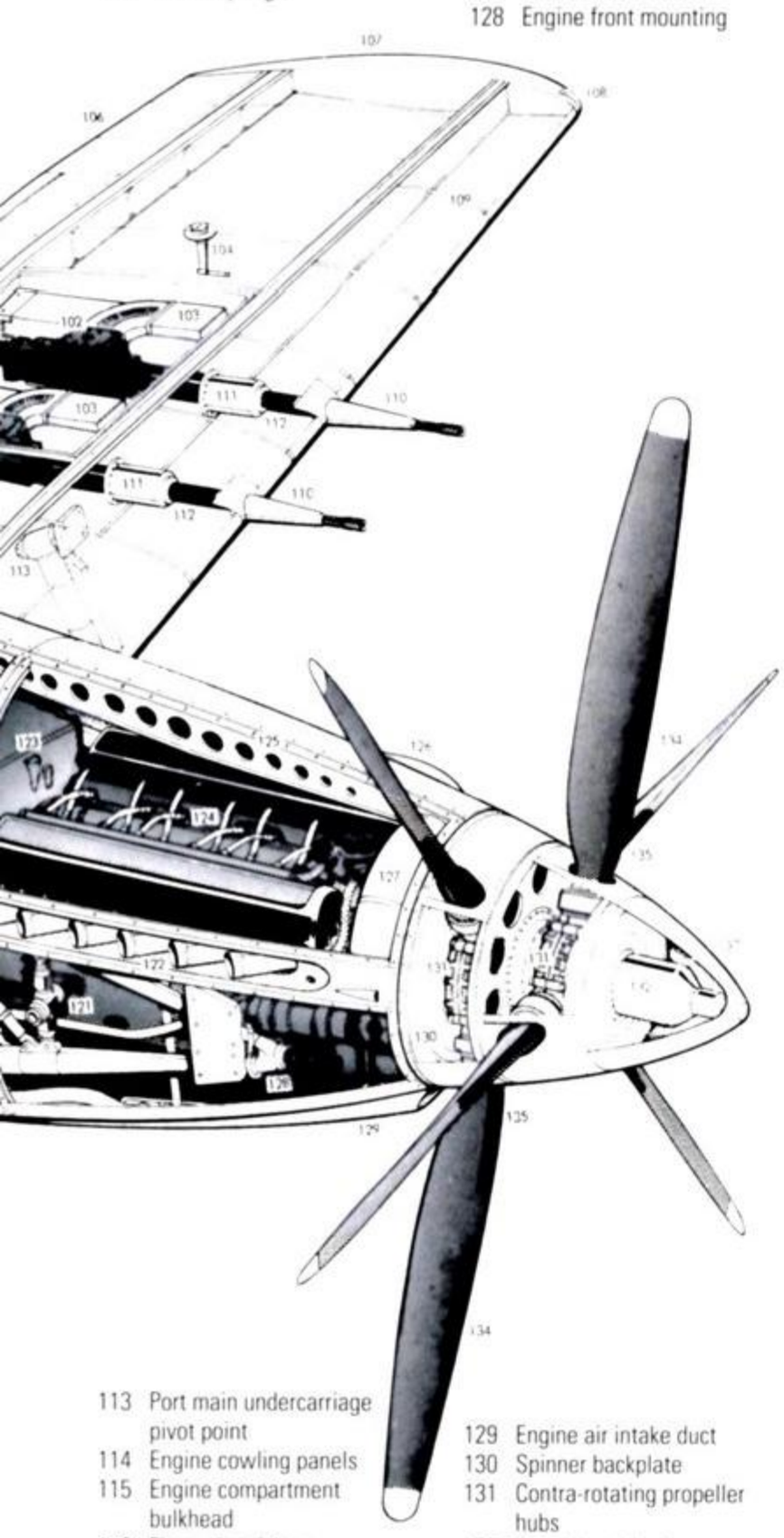
The obvious place to test this outstanding aircraft was Boscombe Down. This facility was reserved for the 'Mafia' of established builders, which in any case had good airfields adjoining their factories. Martin would have been quite happy to return to the rolling Berkshire downs at Harwell, but some one in the Ministry decreed that the M.B.3 should be flown at Wing, a tiny RAF station in Buckinghamshire surrounded by small fields and trees. The Ministry refused to listen to Martin's protests.

By almost superhuman efforts the M.B.3 was trucked to this supremely unsuitable airfield in August 1942, and Captain Baker flew it on the last day of the month. By this time it had been fitted with a completely new canopy of the teardrop type (one of the first in the world), with the coaming behind the cockpit removed. Even without its six cannon installed, the new prototype made a profound impression on Wing's RAF personnel. Not least of its achievements was to run up to full power without any need to hold down the tail. In the air the only problem was high coolant temperatures, but this was quickly rectified. Speed and manoeuvrability were better than predicted, and the spring-tab flight controls were considered pretty well perfect from the outset.

The only problem was the complicated Napier engine. It never ran smoothly, gave incessant trouble and oozed oil all over the front of the aircraft. On 12 September 1942 Baker had a strange premonition, and said to Martin, "Something is not quite right, and I don't know what it is." Later that day the Sabre suddenly lost power on take-off, cut in again and then, with the aircraft beginning to climb away from the airfield, it cut dead. Baker had no choice but to put the aircraft down straight ahead. Tragically, one wing hit a tree stump. The aircraft cartwheeled, broke up, and the remains of the fuselage caught fire immediately. Fortunately for Baker, he was almost certainly killed before being burned.

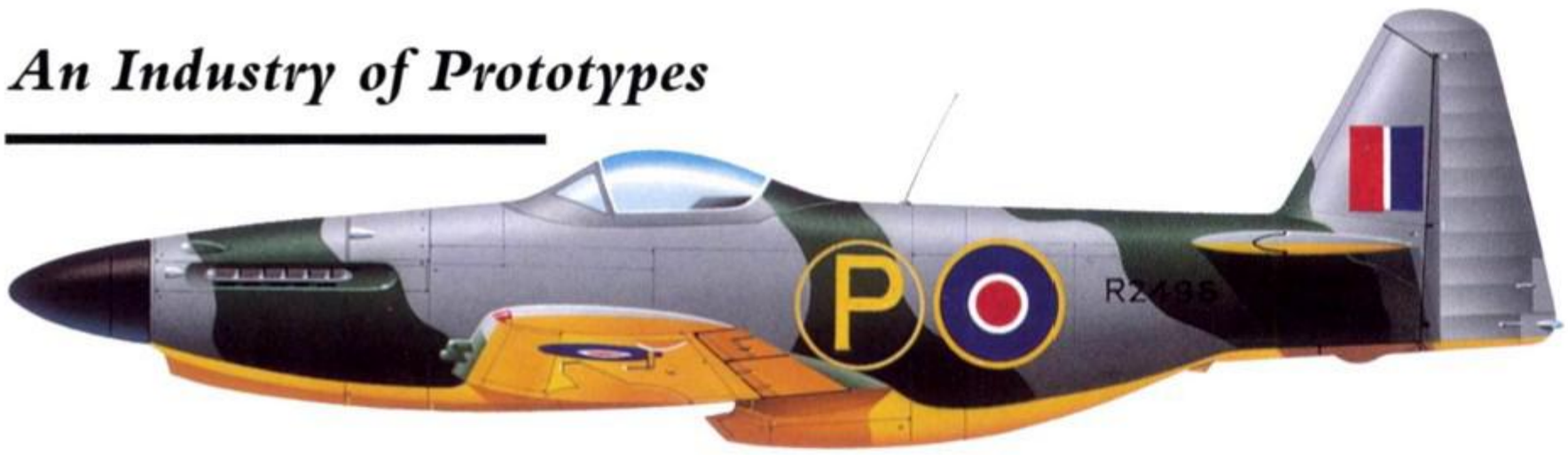
This was a shattering personal blow to Martin, because he and 'dear Val' had been a particularly close team. It took months for him to resume his usual outgoing busy routine, even though the MAP kept pressuring him to complete the remaining two prototypes in an

If the cowling of the M.B.3's Sabre was considered masterful, that of the M.B.5's Griffon was pure perfection. The ejector exhausts were located in a shallow trough, reducing drag while still maintaining a small but useful thrust effect.



108 Port navigation light
109 Leading-edge skin panel joints
110 Cannon barrel fairings
111 Cannon mountings
112 Recoil springs
113 Port main undercarriage pivot point
114 Engine cowling panels
115 Engine compartment bulkhead
116 Fire extinguishers
117 Upper engine bearer strut
118 Exhaust fairing panel
119 Two-stage supercharger
120 Lower engine bearer strut
121 Rear engine mounting
122 Exhaust stubs
123 Intercooler
124 Rolls-Royce Griffon 83 liquid-cooled 12-cylinder Vee engine
125 Engine cowling strut
126 Cowling blister fairing
127 Coolant header tank
128 Engine front mounting
129 Engine air intake duct
130 Spinner backplate
131 Contra-rotating propeller hubs
132 Propeller pitch change mechanism
133 Spinner
134 De Havilland six-bladed contra-rotating constant-speed propeller
135 Propeller blade root de-icing cuffs

The M.B.5 retained the wings and undercarriage of its predecessor, although the armament was reduced to four instead of six cannon. The propeller was originally a Rotol unit, later replaced by one from de Havilland.



The single M.B.5 spent much of its career in a standard grey/green camouflage, with yellow undersides and fuselage 'P' to signify its prototype status. Here the aircraft is depicted in its final configuration with enlarged tailplanes, which extended well forward of the vertical fin.

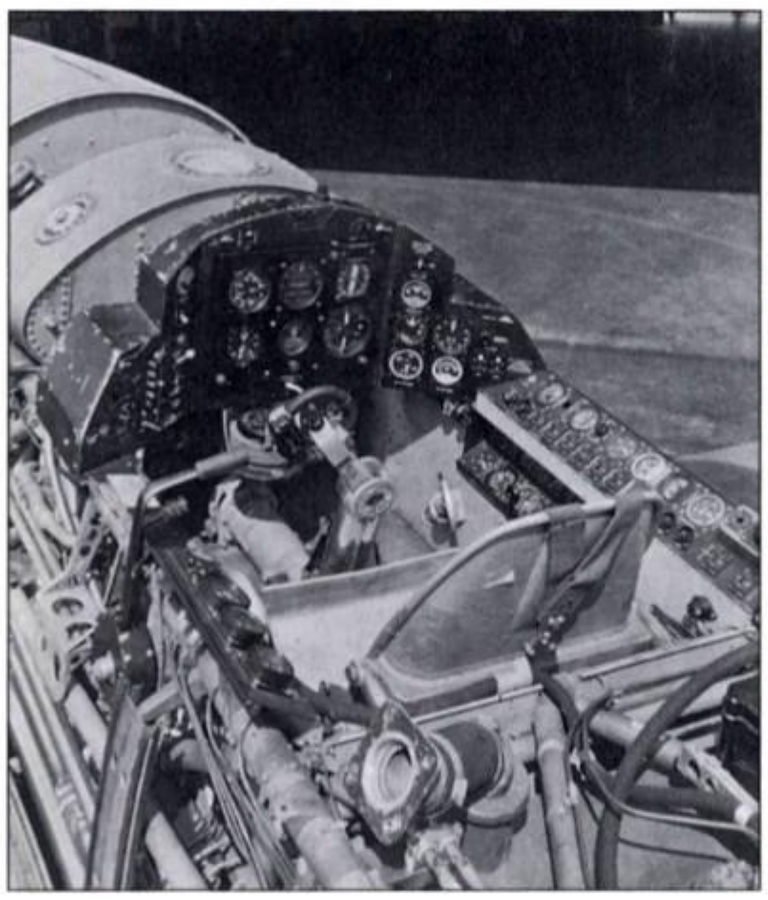
impossible three months. Eventually, the financial situation was sorted, and, in view of what had happened, the Ministry no longer forced Martin to accept another Sabre. Instead, he was allowed to have the engine he had originally wanted: a Rolls-Royce Griffon.

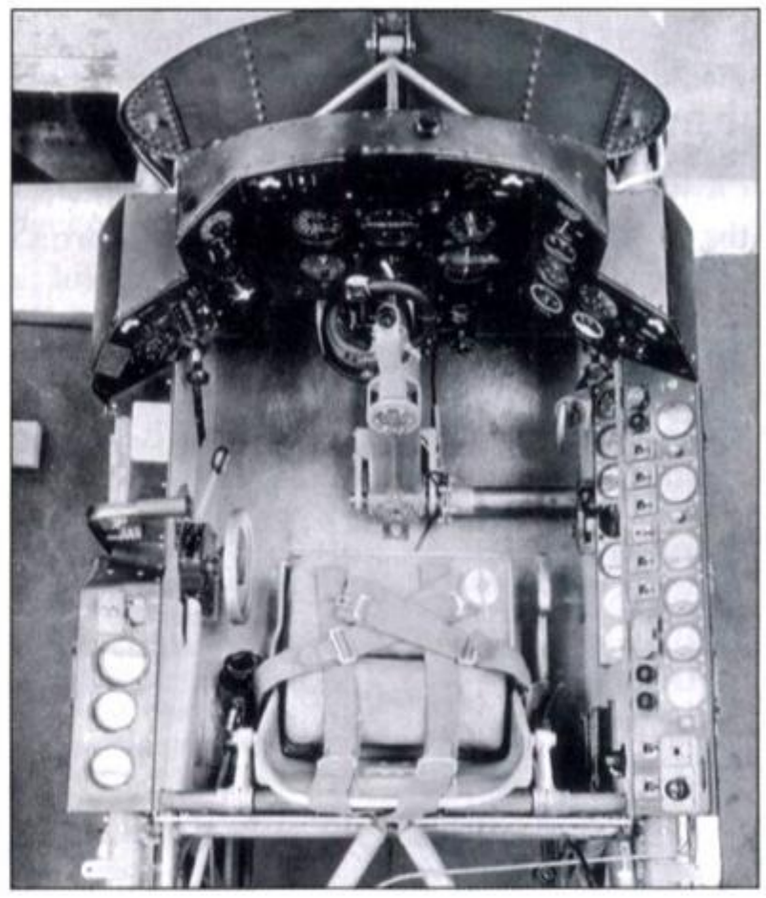
In late 1941 Martin, urgently seeking an alternative to the Sabre, had done preliminary drawings of the M.B.4, a minimum-change fighter powered by a Bristol Centaurus 18-cylinder sleeve-valve radial of 2,500 hp (1865 kW). It could have been a superb aircraft, but there was no way he could get the MAP to show interest. Thus, the designation of the Griffon-engined aircraft was M.B.5. In the course of 1943, by mutual consent, the third M.B.3, believed to have had R2499 allocated, was cancelled.

Two-stage Griffon

By late 1942 the Griffon was being further developed, and in the course of 1943 Rolls-Royce produced the Mk 83 version with a two-stage supercharger and a drive to a six-bladed Rotol contra-rotating propeller. This engine was rated at 2,305 hp (1720 kW) at full-throttle height of 500 ft (152 m). The contra-prop avoided the enormous torque problem on take-off, and of course the Griffon was a simpler engine than the Sabre.

Thus, the second M.B.3, serial R2496, ended up as the M.B.5, a considerably modified aircraft. Apart from the change in engine the biggest rethink was to eliminate the wing radiators. Influenced by the Mustang engineers, Martin relocated the coolant radiator, oil cooler and the new intercooler required by the two-stage engine in a profiled duct under the rear fuselage. This moved the centre of gravity aft so that, even allowing for the heavy contra-prop, the engine had to be moved forward, increasing overall length by 29 in (0.74 m). Another major change was that Martin had second thoughts about how to give the pilot the best view, and moved the cockpit forward over the wing.





The cockpit of the M.B.5 had some notable features, including a proper floor, 'wrap-round' dash board and the extensive use of the side consoles for secondary instruments. This left the central dash remarkably clear, allowing the pilot instant uncluttered viewing of the primary flight instruments. The control column, with its centrally positioned radio mike switch, hinged from the floor for pitch control, but hinged half-way up for roll control. The large lever on the left-hand side controlled the propeller pitch by increasing or decreasing rpm. Below it was the throttle quadrant and pitch trim wheel. Rudder trim was controlled by the turn handle at the pilot's left side. An A&AEE report on the M.B.5 dated 1 March 1946 noted that "The layout of the cockpit is excellent [and] might very well be made a standard for normal piston-engined fighters."

The basic fuselage truss, wing, tail and landing gear were almost unchanged from the M.B.3. Extending the fuselage enabled two fuel tanks to be accommodated, with the slightly increased capacity of 200 Imp gal (909 litres). To reduce weight, the low-pressure pneumatic system was replaced by a Hymatic system operating at 350 psi (2413 kPa). To fall into line with standard fighter armament, Martin modified the wing to house four cannon instead of six, of the short-barrelled Mk V type as fitted to the Tempest, with the muzzles almost in line with the leading edge. Other modifications included fitting longer spring tabs on the ailerons and both spring and trim tabs to the elevators. Behind the teardrop canopy was a whip antenna for the radio.

Lack of official support

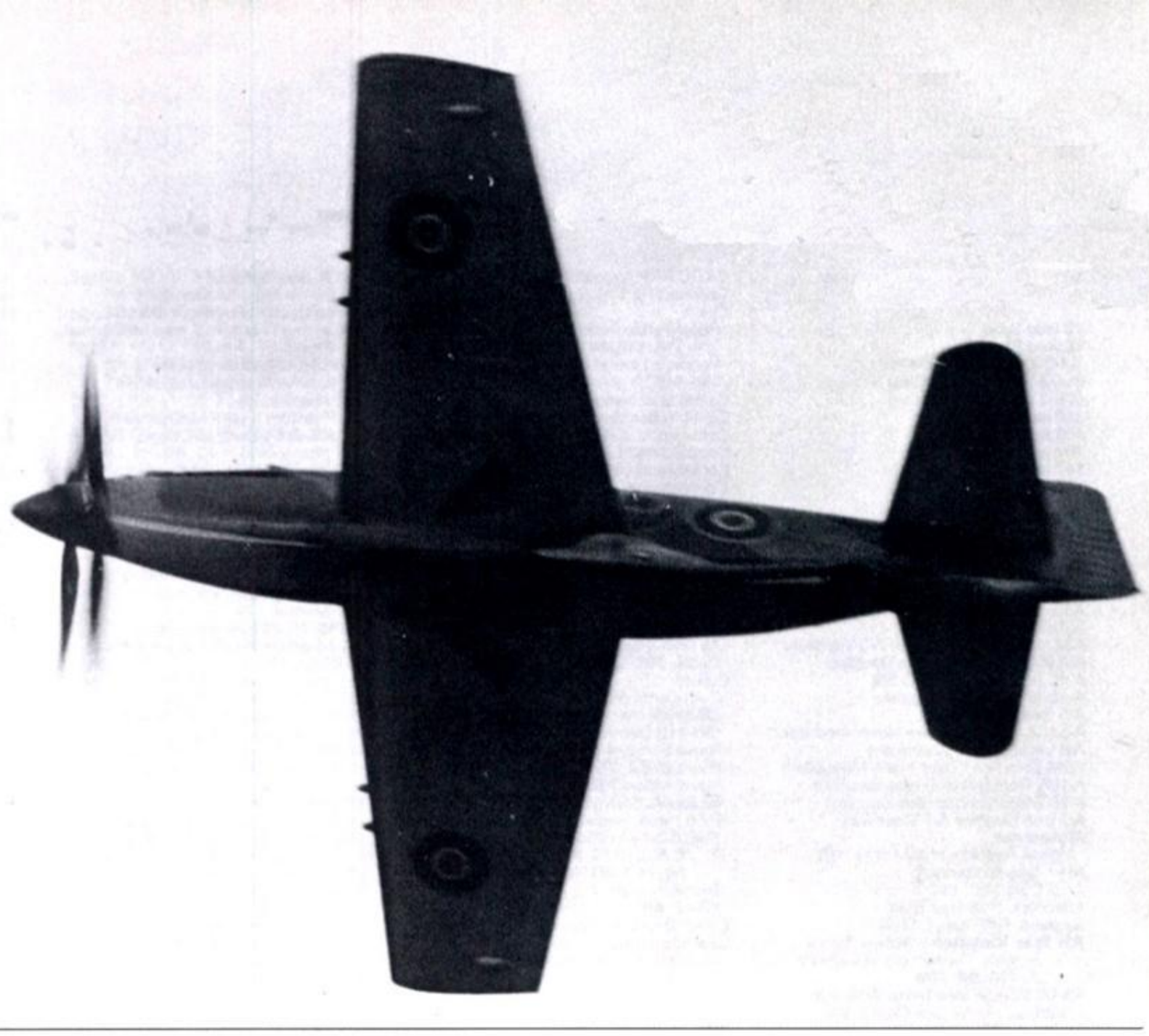
By 1943 MAP officials had got to know Jimmy Martin better. They could have said, "This man is a brilliant mechanical engineer, and somehow he seems to know about aerodynamics as well, so instead of operating literally as a one-man band we ought to let him have several hundred technical staff, tell him to start flight testing in a matter of days and meanwhile start tooling up a large factory to build M.B.5s." There were certainly plenty of factories engaged in mass-production of useless aircraft. Instead, the attitude was, "This little firm is very useful for making gadgets and doing brilliant bits of jobbing work at short notice, so we'll let Martin keep tinkering with the M.B.5 and perhaps the war will still be on when it eventually flies."

If Baker had been alive he would have been intimately involved in every design decision on

In true Martin-Baker tradition, the M.B.5 required an increase in fin size following its first few flights. With this modification completed, the aircraft demonstrated no handling vices, while recommended equipment changes were remarkably few for such a new aircraft.

The M.B.5 was as attractive to fly as it was to look at, demonstrating superb handling, high speed and sparkling climb performance.

the M.B.5. As it was, Martin had huge emotional reticence to appointing a successor. At last, when R2496 was outwardly almost finished, he asked the MAP to suggest someone. Hives at Rolls-Royce was reluctant to lend any of his pilots, so the officials nominated the test pilot of the M.B.5's propeller company, Rotol. Bryan Greensted accordingly came up from Gloucester to Denham. He refrained from saying, "How on earth can you have built a valuable prototype without any idea who was going to fly it?" and instead marvelled at its brilliant design. He was even more impressed when, on 23 May 1944, the M.B.5 was dismantled after breakfast, put on a Queen Mary trailer, taken to Harwell, reassembled, put through a programme of ground running (using Martin's newly invented simple cable anchoring system), inspected, cleared for flight and then flown very successfully at teatime! It is doubtful if this would have been possible with any other fighter in the world of that period, even a mature aircraft with years of service.



A brilliant flier

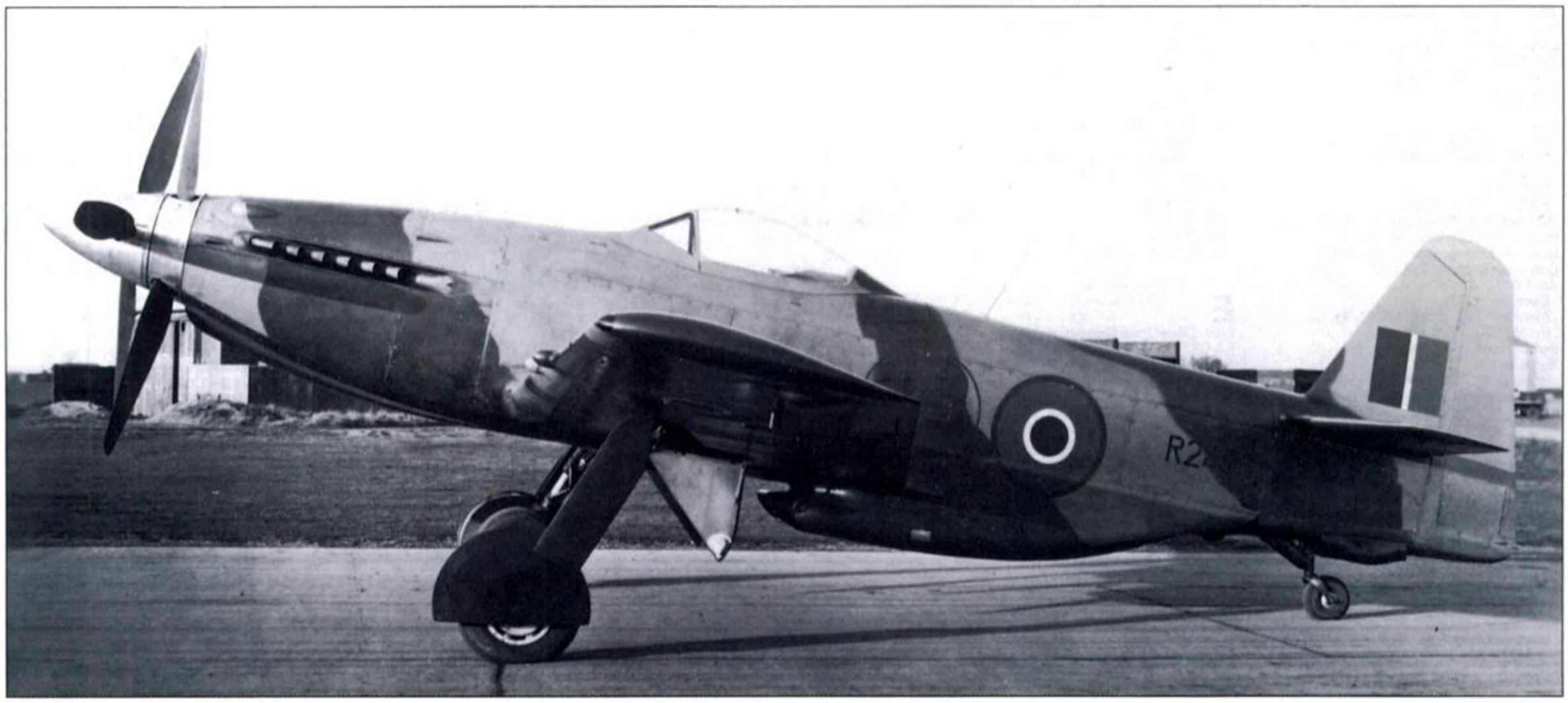
Greensted considered almost everything about the M.B.5 to be brilliant, the only exception being poor directional stability. Like the finless M.B.2, it refused to go the way it was pointing. The problem was probably failure to take account of the side area of the contra-rotating propellers on the longer nose. The cure was to increase the size of the fin and rudder, just as had been done with the M.B.2. For good measure, Martin also designed a bigger tailplane and elevators. Thereafter the M.B.5 was a truly outstanding fighter. Indeed, there is hardly a single pilot who flew it – and the author only just missed this pleasure – who did not think it the greatest piston-engined fighter ever built.

Once it had its larger vertical tail, there was virtually nothing to criticise. In its entire career it had only one bad moment, in October 1945, when it suffered a major engine failure. Surrounded by oil and smoke, Greensted reached up and jettisoned the hood, badly wrenching his arm, and the hood then struck the tailplane. Fortunately, the impact did not cause enough damage to induce loss of control, and Greensted managed to recover to the runway. Unfortunately, all this happened in front of the Prime Minister, the Chief of the Air Staff and a host of other VIPs at an important display of British and ex-German aircraft at Farnborough.

Brilliant as the M.B.5 was, once the war was over it had no chance. Future fighters were going to be jet-propelled, and in any case the newly elected Labour government had no interest in spending money on hardware for defence. Martin did toy with drawing various jet fighters, but with little hope of ever being able to build any. By this time he had found the product that was to make the name of Martin-Baker world-famous: the ejection seat.

There is no reason to doubt that, had James Martin been born 25 years earlier, he would have produced outstandingly superior warplanes in World War I. By the 1930s, no matter how good his creations, he had virtually no chance of breaking into the established clique of British fighter design firms. As a result, the RAF fought World War II with fighters which were unnecessarily difficult to maintain and repair. The only 'erks' (ground crew) who realised this were the few who encountered Martin's fighter prototypes. **Bill Gunston**

The M.B.5 is seen here as presented to the A&AEE for trials at Boscombe Down in early 1945 with its enlarged tail but with the original small tailplane. Sadly, nothing tangible remains of Martin-Baker's fighter programme, although the M.B.5 is believed to have still been present at the company's Chalgrove facility in the 1960s.



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